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Research Report 1684

An Investigation of Simulator Sickness in a Tank Driver Trainer

Donald R. Lampton, Ronald E. Kraemer,
Eugenia M. Kolasinski, and Bruce W. Knerr
U.S. Army Research Institute

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13. ABSTRACT (Maximum 200 words):

This report describes our examination of the incidence and severity of simulator sickness symptoms resulting from use of a computer-based tank driver trainer. Symptoms experienced by trainees were measured using questionnaires, interviews, and a test of balance. Results from the first training session indicated that approximately 15% of the trainees reported some form of discomfort that interfered with training. Symptoms related to nausea were more prevalent than either eyestrain or dizziness. Subsequent training sessions resulted in significantly less simulator sickness than the first. Our recommendations for reducing simulator sickness primarily addressed the treatment of trainees before, during, and after training, and the selection and the use of training scenarios. The recommendations are being implemented in the training program. Areas for future research are outlined.

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FOREWORD

A primary goal of Army training is to reduce training costs while maintaining training effectiveness. To meet this goal the U.S. Army Armor School (USAARMS) has procured M1 Tank Driver Trainers (TDT) and incorporated them in a Program of Instruction (POI) for training M1/M1A1 crewmen. From March 1993 through December 1994, 8,021 soldiers have been trained on the simulators. They have driven some 159,635 simulated miles.

The TDT provides an excellent example of how computer-based simulators can provide training that is less expensive, safer, and more flexible than operational equipment. However, as with many simulators that depict movement, simulator sickness is a concern because it can potentially degrade training effectiveness and affect the well-being of trainees. By definition, simulator sickness is sickness or discomfort resulting from performing a task in a simulator: the same symptoms would not result from performing the task in the real world.

This research was performed at the request of the Assistant Deputy Chief of Staff for Training, U.S. Army Training and Doctrine Command (ADCS-T TRADOC). He asked the U.S. Army Research Institute for the Behavioral and Social Science (ARI) to determine if TDT training was being affected by simulator sickness and, if so, ways to either prevent or alleviate it. This research was conducted through the joint efforts of the Simulator Systems Research Unit, Orlando, the Armored Forces Research Unit, Fort Knox, and the Rotary-Wing Aviation Research Unit, Fort Rucker.

The results of this research were briefed to the Commander, 1st Armored Training Brigade (1st ATB), USAARMS, Fort Knox, KY on 29 July 1994; Project Manager for Training Devices, Simulation, Training and Instrumentation Command (STRICOM), Orlando, FL on 12 September 1994. In addition, a Letter Report providing preliminary findings of simulator sickness in the TDT was provided to the ADCS-T TRADOC and 1st ATB, USAARMS.

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AN INVESTIGATION OF SIMULATOR SICKNESS IN A TANK DRIVER TRAINER

EXECUTIVE SUMMARY

Requirement:

Based on his observations during a visit to the M1 Tank Driver Trainer (TDT) facility at Fort Knox, the Assistant Deputy Chief of Staff for Training, U.S. Army Training and Doctrine Command (ADCS-T TRADOC), requested the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) to determine if TDT training was being affected by simulator sickness and, if so, ways to either prevent or alleviate it. Simulator sickness refers to unwanted side effects and aftereffects that may result from using simulators such as flight or driver training simulators. When simulator sickness occurs, common symptoms include nausea, dizziness, and headache or eyestrain. Simulator sickness is a major concern because it can potentially degrade training effectiveness and affect the well-being of trainees.

Procedure:

We collected baseline data on the incidence and severity of simulator sickness symptoms reported by a One Station Unit Training (OSUT) company of 115 trainees during their first TDT training sessions. Simulator sickness symptoms were measured using questionnaires, interviews, and a test of balance. For comparison purposes, we also measured symptoms for some of the same trainees following their first field driving session with actual M1 tanks.

In addition to collecting data from the OSUT company trainees, we interviewed 21 of the 54 TDT Instructor/Operators (I/Os) concerning their observations on simulator sickness. Also, I/O records of simulator sickness were tabulated for seven companies that had previously trained with the TDT.

Findings:

Most trainees reported little or no discomfort during their first training session with the TDT. About 15% of the trainees interviewed responded that simulator sickness interfered with their training; for example, exercises were suspended or terminated. Symptoms related to nausea were more prevalent than either eyestrain or dizziness. Approximately 6% of the trainees reported vomiting. Almost all of the trainees, even those who reported simulator sickness, stated that they enjoyed the TDT training sessions. The few trainees who rated themselves as susceptible to motion sickness prior to their first use of the

TDT were more likely to report simulator sickness than those who did not rate themselves as susceptible. However, some trainees who rated themselves as "not at all" susceptible nonetheless reported simulator sickness. Subsequent training sessions resulted in significantly less simulator sickness than the first. Driving the actual M1 tank did not produce symptoms of simulator sickness.

I/O records of seven OSUT companies that had completed training on the TDT indicated that about 27% of the trainees experience discomfort, to the extent that it merited recording, at least once during the entire TDT POI. The I/O records indicated that the incidence of simulator sickness varied greatly across scenarios; 5 of the 22 scenarios accounted for about 80% of the incidence of simulator sickness. The five scenarios with the highest sickness rates were chronologically the 1st through 4th and the 6th scenarios presented to the trainees. Because the scenarios were almost always presented in the same order, we could not determine if these five scenarios have characteristics that are more likely to produce sickness than the others, if simulator sickness declines as a function of the number of sessions a trainee has in the TDT, or a combination of these or other factors. (Previous research has indicated that symptoms decrease with experience with a simulator.)

Utilization of Findings:

The symptoms, incidence, and severity of simulator sickness observed with the TDT appeared no worse than those reported in a roughly comparable study of an Israeli tank driver trainer. Given the nature of the tasks to be trained (driving over rough terrain, for example) some simulator sickness should be expected. We do not believe that the TDT has any unique problems of simulator sickness in comparison with other simulators. We did identify some changes to the ways that the TDT is used that could potentially reduce the incidence and severity of simulator sickness in the TDT. These recommendations primarily address the treatment of trainees before, during, and after TDT training and the selection and use of training scenarios. The recommendations are being implemented in the TDT training program.

AN INVESTIGATION OF SIMULATOR SICKNESS IN A TANK DRIVER TRAINER

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AN INVESTIGATION OF SIMULATOR SICKNESS IN A TANK DRIVER TRAINER

Introduction

Simulator sickness is a potential problem with any simulator that portrays self-movement to the trainee, whether that movement is flying in a fixed or rotary wing aircraft, driving or riding in a vehicle, or moving on foot. Simulator sickness refers to unwanted side effects and aftereffects that may result from using simulators such as flight or driving training simulators. When simulator sickness occurs common symptoms include nausea, dizziness, and headache or eyestrain. Simulator sickness is a concern because it can potentially degrade training effectiveness and affect the well-being of trainees.

Based on his observations during a visit to the M1 Tank Driver Trainer (TDT) facility at Fort Knox, the Assistant Deputy Chief of Staff for Training, U.S. Army Training and Doctrine Command (ADCS-T TRADOC), requested the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) to look into the issue of TDT simulator sickness and ways to either prevent or alleviate it. Research psychologists from three ARI Research Units formed a task force to examine simulator sickness in the TDT. Researchers were selected from the ARI Armored Forces Research Unit/Fort Knox because of their expertise in conducting research on a non-interference basis and because the TDT training site is located at Fort Knox. Researchers at the Simulator Systems Research Unit/Orlando have experience in measuring and preventing simulator sickness as part of a program examining training applications of virtual reality technology. Researchers at ARI's Rotary-Wing Aviation Unit/Fort Rucker have years of experience in dealing with simulator sickness in flight simulators and are involved with the National Driving Simulator in Iowa.

The TDT site at Fort Knox, Ky. is a modern training facility at which hundreds of troops train each week. We were allowed to collect data through the cooperation of the Commander, 1st Armor Training Brigade. Our research was conducted on a non-interference basis. We recorded simulator sickness in the context of the normal TDT Program of Instruction, but we were not able to manipulate any variables. We did not control task characteristics or exercise duration. We did not manipulate software or hardware characteristics of the simulators, nor did we select or assign trainees or Instructor/Operators (I/Os) to conditions.

Even under laboratory conditions measurement of simulator sickness is not a precise science. Researchers continue to seek to identify those factors critical to simulator sickness and to determine the implications of simulator sickness for training effectiveness and trainee well-being.

This report presents background information about simulator sickness in general, describes the procedures for and results of measuring simulator sickness with the TDT, and lists our recommendations for ways to potentially reduce simulator sickness in the TDT.

Background

The M1 Tank Driver Trainer

The TDT is a computer-based simulator designed to provide training for the driver of the M1 Abrams main battle tank. The TDT includes a completely enclosed driver compartment which replicates the interior of the M1 tank's driver compartment. The TDT driver compartment is situated upon a motion platform capable of producing six degrees of motion (pitch, roll, yaw, heave, surge, and sway). Three display screens present computer-generated imagery simulating the view from the driver's hatch. Both closed hatch, in which the driver peers through protective vision blocks, and open hatch views can be simulated. (A detailed description of the TDT is provided in APPENDIX A.)

The TDT provides an excellent example of how computer-driven training simulators can provide training that is less expensive, safer, and more flexible than training on operational equipment. Operation of an actual tank costs about $92 per mile. In contrast, the TDT costs less than $6 per mile (including instructor/operator salary, contractual maintenance, and electricity). The TDT will save millions of dollars over its life cycle.

Training in the TDT is safer than training in an actual tank. In a tank, unlike in the cockpit of many aircraft or the front seat of most ground vehicles, the "driving instructor", the Tank Commander (TC), can not sit next to the trainee or take control of the vehicle in an emergency. The driver is physically separated from the other crew members. The TC can not see or touch the driver and communication is limited to speaking through the Combat Vehicle Crewman (CVC) intercom.

Because of the power and mass of a tank, a driving error can lead to injury or death of the tank crew members or bystanders, and damage to the tank and other equipment or facilities. For example, during driving training the TC stands on a support within the turret so that part of his upper body is above a hatch. If the trainee drives erratically, brakes abruptly or hits an obstacle for example, the TC can be thrown out of the tank.

The TDT can represent a wide range of driving conditions. The TDT can simulate driving at day or night, and under different weather conditions such as haze, fog, ice, or snow. A wide

variety of terrain can be depicted such as urban areas, rolling hills, desert, or mountainous areas. In addition, the TDT can represent other moving vehicles with which the trainee must react or coordinate movement.

Several improvements to the TDT were in the planning stage at the time we measured simulator sickness with the TDT. One of these changes involves the implementation of a computer-mediated system to score various aspects of trainee driving performance. No useable trainee performance scores were available when we measured simulator sickness with the TDT.

Tank driving training involves much more than learning to safely and efficiently move from point A to point B. Although the complexity of tank driving in combat is beyond the scope of this report we believe it is safe to assume that a well-trained driver contributes significantly to the offensive and defensive capabilities of a tank in actual combat.

The TDT provides a cost-effective, safe, and flexible complement to training with actual tanks. Unfortunately, as with many simulators that depict movement, simulator sickness is a concern because it can potentially degrade training effectiveness and affect the well-being of trainees.

Simulator Sickness

Simulator sickness is a potential problem with any simulator that portrays self-movement to the trainee, whether that movement is flying in a fixed or rotary wing aircraft, driving or riding in a vehicle, or moving on foot. Simulator sickness refers to unwanted side effects and aftereffects resulting from use of simulators such as flight simulators or driver training simulators. These effects are similar to, but not limited to, motion sickness symptoms such as nausea and dizziness. In addition, ocular discomfort, such as eye strain or difficulty in focussing, is a dimension of simulator sickness. Simulator sickness is a concern because it can potentially degrade training effectiveness and affect the well-being of trainees (Kennedy, Hettinger, & Lilienthal, 1988).

Simulator sickness may degrade training effectiveness despite the absence of severe symptoms such as vomiting. Discomfort in the simulator may distract the trainee. Simulator sickness may lead to negative transfer of training in that the trainees may adopt behaviors that mitigate sickness in the simulator but will be detrimental if transferred to the actual vehicle. Aftereffects involving the sense of balance, such as postural disequilibrium (ataxia), or flashbacks could possibly impair the trainees' ability to drive safely after leaving the simulator. The training value of a simulator is reduced if

simulator sickness forces a decrease in the frequency or duration of use of the simulator.

Discomfort resulting from use of a simulator should not necessarily be interpreted as simulator sickness (Kennedy et al., 1987). Simulator sickness refers to sickness or discomfort resulting from performing a task in a simulator for which performance of the same task in the real-world does not produce similar sickness or discomfort. A (hypothetical) example of simulator sickness: trainees become ill while driving through a motor pool in the TDT, but do not become ill when driving a real tank through a motor pool. If both the simulated and real-world tasks produce sickness, then the sickness experienced in the simulator should not be considered simulator sickness. A (hypothetical) example: trainees become ill in the TDT while driving a slalom course, however, a similar real-world tank driving task also makes trainees ill.

Simulator sickness is thought to result, at least in part, because simulated movement results in a conflict between the human body's mechanical systems and visual systems for sensing movement. That is, the body detects that the relationship between what one feels and sees during "movement" in a simulator differs from the relationship between what one feels and sees during movement in the real world. Treisman (1977) proposed that a change or conflict in the relationships between the senses may be interpreted by the body as an indication that toxins (poison) have been ingested. Therefore, nausea reaching the stage of vomiting would have survival value by removing the toxins. According to this explanation simulator sickness is an unfortunate result of the inappropriate activation of this nausea response.

Table 1 (from Kolasinki, 1995) lists some of the factors that previous research has indicated affect simulator sickness. Note that the characteristics of the simulator itself are only part of the simulator sickness picture. The characteristics of the tasks being simulated and the characteristics of the trainees are also critical determinants of simulator sickness.

Table 1

Potential Factors Associated With Simulator Sickness in Virtual Environments

Individual	Simulator	Task
age	binocular viewing	altitude above terrain
concentration level	calibration	degree of control
ethnicity	color	duration
experience with real-world task	contrast	global visual flow
experience with simulator (adaptation)	field of view	head movements
flicker fusion frequency threshold	flicker	luminance level
gender	inter-pupillary distance	method of movement
illness and personal characteristics	motion platform	rate of linear or rotational acceleration
mental rotation ability	phosphor lag	self-movement speed
perceptual style	position-tracking error	sitting versus standing
postural stability	refresh rate	type of application
	resolution	unusual maneuvers
	scene content	vection
	time lag (transport delay)	
	update rate (frame rate)	
	viewing region	

Kolasinski discussed dozens of factors thought to be involved in simulator sickness. Those especially relevant to this report are: experience with the simulator; and illness, sleep loss, and emotional stress. Previous research, mostly involving flight simulators, indicates that, all other things being equal, a trainee is most susceptible to simulator sickness during the first session with a simulator. For most trainees, simulator sickness declines during subsequent sessions. Other research has indicated that illness, sleep loss, and emotional stress may increase susceptibility to simulator sickness.

Questionnaires and symptom checklists are the usual means of measuring simulator sickness because there are many different symptoms of simulator sickness; measuring just one sign or symptom would not be sensitive (Kennedy & Fowlkes, 1992). A commonly used questionnaire to measure simulator sickness in flight simulators is the Simulator Sickness Questionnaire (SSQ) which was developed by the ESSEX Corporation (Kennedy, Lane, Berbaum, & Lilienthal, 1993).

The SSQ symptom list consists of 16 symptoms which are rated by the trainee on a 4-point scale (0=none, 1=slight, 2=moderate, 3=severe). These ratings form the basis for three subscale scores - Nausea, Oculomotor Discomfort, Disorientation - as well as a Total Severity score. The symptoms making up the three subscales are: Nausea - general discomfort, increased salivation, sweating, nausea, difficulty concentrating, stomach awareness, and burping; Oculomotor - general discomfort, fatigue, headache, eyestrain, difficulty focusing, difficulty concentrating, and blurred vision; and Disorientation - difficulty focusing, nausea, fullness of head, blurred vision, dizzy (eyes open), dizzy (eyes closed), and vertigo. The Total Severity score uses all of the symptoms. The Total Severity score is based on a weighted (3.74) sum of the symptom scores. The subscale weights are 9.54 for nausea, 7.58 for Oculomotor Discomfort, and 13.92 for Disorientation. Table 2 depicts the contribution of the individual symptoms to each subscale.

Table 2

Simulator Sickness Questionnaire (SSQ)

Subscales		
Nausea	Oculomotor Discomfort	Disorientation
general discomfort	general discomfort	difficulty focusing
increased salivation	fatigue	nausea
sweating	headache	fullness of head
nausea	eyestrain	blurred vision
difficulty concentrate	difficulty focus	dizzy (eyes open)
stomach awareness	diff concentrate	dizzy (eyes closed)
burping	blurred vision	vertigo

The Total Severity score reflects the overall extent of symptom severity and is therefore the best index of whether or not a sickness problem exists. The SSQ subscale scores can provide diagnostic information as to the specific nature of the resulting sickness. Kennedy et al. (1993) have published baseline SSQ data obtained from Navy Flight simulators which can serve as a comparison for other systems.

In addition to the symptoms identified by the SSQ, loss of sense of balance, also called postural disequilibrium or ataxia, is another potential aftereffect of simulator exposure. Thomley, Kennedy, and Bittner (1986) suggested that ataxia is due to a disruption in balance and coordination resulting from the visual and vestibular adaptation to conflicting cues occurring during simulator exposure. Although sophisticated devices are being developed to measure ataxia, current research into simulator sickness often uses something similar to the "road sobriety test" administered by traffic officers.

Published recommendations for alleviating simulator sickness have for the most part been directed towards flight simulators. Kennedy et al.,(1988) listed several guidelines or rules for reducing simulator sickness which have been implemented at Navy flight training sites. They pointed out that persons most susceptible to simulator sickness are those new to the simulator, and especially those with extensive flight time. They stated that adaptation of the individual is one of the strongest and most potent fixes for simulator sickness. They recommended that to optimize adaptation training sessions should be a minimum of one day and a maximum of seven days apart. They stated that simulator training sessions should never last more than two hours and that with particularly nauseagenic scenarios time-outs should be used extensively.

Frank and Casali (1986) noted that some trainees may benefit from a briefing by the instructor prior to their initial session on the simulator. The briefing should address what to expect in the simulator and how to deal with any problems they experience. They stated:

> Some simulators may have an aura of sickness about them, fostered through anecdotes and gossip of former users. Briefings may prove essential with these 'notorious' devices, to eliminate any pre-bias a new trainee may have developed through talking with others. If briefings are not used, by simple power of suggestion, naive trainees may be predisposed to sickness in a particular simulator because they feel the sickness is imminent or unavoidable, perhaps expected of them. (p. 3,4)

McCauley and Sharkey (1992) proposed that simulator sickness is inevitable for a substantial proportion of users of flight and driver simulators. They stated that engineering fixes to simulator sickness are already in the region of diminishing returns. However, they noted that although even excellent engineering may not prevent sickness, poor engineering or calibration will contribute to simulator sickness.

Perhaps because of the characteristics of the tasks to be trained, driving training simulators may be especially prone to produce simulator sickness. Casali and Wierwille (1980) stated that "One of the most serious yet least publicized shortcomings associated with the use of vehicle simulators, especially driving simulators, is a recurring malady termed 'simulator sickness'" (p. 741). Casali (1986) noted that most driving simulators, both those with and without motion platforms, have had problems with simulator sickness.

As a final background note we quote from the beginning and end of an article by Lerman et al.(1992) which described their investigation of sickness among trainees using an Israeli tank driving simulator:

> A military tank driving simulator has recently been introduced as a training aid for tank drivers in the Israel Defense Forces. Reports of nausea and vomiting among the first users of the simulator launched our investigation of the possible existence of a motion sickness-like syndrome among simulator drivers. (p. 610)
>
> Given the vast application potential of tank simulators and the large investments they entail, it is incumbent upon simulator users, designers, and researchers to

> recognize, address, and solve the simulator sickness problem. (p. 614)

Purpose of the Research

The critical questions addressed by this research were:

> What are the incidence, severity, and dimensions of symptoms of simulator sickness (if any) resulting from training with the TDT?
>
> How do these symptoms compare with those produced by driving the actual M1 tank?
>
> Does the pattern of simulator sickness change with repeated use of the TDT?
>
> Can we identify those individuals most susceptible to simulator sickness prior to their use of the simulator?
>
> Does presenting trainees with a pre-exposure questionnaire make them more likely to report symptoms?

Research Approach

Overview

We used a multi-faceted approach to measure simulator sickness in the TDT:

An OSUT company of TDT trainees was administered background information questionnaires, modified SSQs, interviews, and tests of postural stability following training sessions on the TDT and actual M1 tanks.

We examined I/O records of simulator sickness for six companies that had previously trained with the TDT.

We interviewed TDT I/Os on various aspects of simulator sickness.

A researcher from the ARI unit at Fort Rucker examined TDT engineering documents for factors such as the specifications of maximum allowable asynchrony between visual display and motion platform operations.

We conducted a test-drive of the TDT.

Research Design

Research with other simulators has indicated that the highest incidence of simulator sickness occurs during the initial training sessions. Therefore, we observed trainees during their first session on the TDT.

The central element of our plan was the measurement of simulator sickness in one company of trainees during their first TDT session and then again after their first M1 field session. Comparison of these data would allow us to determine if TDT training was resulting in symptoms which did not occur with training in the actual M1. From these results we would determine what, if any, additional research was needed to address simulator sickness in the TDT.

The interval (almost two months) between the first TDT session and the first M1 field session provided the opportunity to examine changes in simulator sickness over time. That is, we periodically measured simulator sickness during subsequent TDT training sessions for some of the trainees in the company.

The SSQ was our primary data collection instrument. There were several reasons for using the SSQ. Administration of the SSQ is fast and simple. In addition, the SSQ has been used extensively in evaluation of other training simulators. We added questions to address claustrophobia and to differentiate between warm sweating (normal sweating induced by body heat) and cold sweating (stress-induced sweating). In addition, we included symptoms that had been used in previous versions of the SSQ to produce the 30 item version of the SSQ which is shown in APPENDIX B. We pilot-tested and modified the SSQ to assure that the wording was appropriate for TDT trainees.

In measuring simulator sickness we felt it was desirable to take into account that some trainees may already have symptoms before they use the training device. For example, if the trainee has a headache before training on a simulator, that discomfort should in some way be taken into account in interpreting symptoms reported on exiting the simulator. (The concern is not just that some pre-training problem will carry over to post training, but also that the pre-training problems may increase susceptibility to simulator sickness.) One approach is to give the SSQ both before and after TDT training. A conceivable problem with this approach is that seeing the list of symptoms beforehand may sensitize the trainee to those symptoms or in some other way lead to exaggerated reporting of simulator sickness. Therefore, of the trainees who completed the SSQ, half were given the SSQ both before and after training in the TDT, the other half only completed the SSQ after exiting the TDT.

In addition to the SSQ, we also used interviews of trainees to assess simulator sickness. Use of open-ended interview questions had the potential to identify symptoms, or unanticipated problems, of simulator sickness not dealt with by the SSQ. In addition, we used interviews because of concerns that seeing the list of symptoms on the SSQ might somehow result in an overestimation of the incidence or severity of simulator sickness. The interview (APPENDIX C) began with the question "How do you feel"? asked in a neutral tone of voice by the interviewer. Regardless of the trainee's response, the interviewer then proceeded with a series of increasingly focussed questions addressing the occurrence, severity, and time course of onset of symptoms.

Some parts of the interview were similar to the SSQ in that questions addressed the three primary dimensions of simulator sickness: the occurrence of discomfort related to the stomach, vision, and sense of balance. However, some of the interview questions addressed information not covered by the SSQ. For example, one question was whether or not simulator sickness (if any) was severe enough to interfere with training. Also, one question addressed the comfort of the temperature inside the simulator.

The SSQ and the interview produce subjective measures of simulator sickness; both depend on the trainee to report symptoms that can not always be independently confirmed by the researcher. In contrast, a test of balance is an objective measure. The balance test required the trainees to stand on one foot, with eyes closed and their hands crisscrossed over their chest, and to maintain this posture for as long as possible up to a maximum of 30 seconds.

We collected data on all the company trainees for their first TDT session, and on some of the trainees on several subsequent TDT sessions and their first driving session with actual M1 tanks. The subsequent TDT sessions were the second session, a "middle" session that corresponded roughly to the half-way point of the POI, and the last TDT training session. The number of sessions of TDT training varied across individual trainees, thus we used the labels "middle" and "last".

Postural stability tests were administered to the trainees before and immediately after the training session. About one third of the trainees were interviewed after the session. The others were given the SSQ after the session. Of those trainees receiving the SSQ, about half completed an SSQ before the training session. In summary: for most data collection sessions, of the trainees from which we collected data about one third were interviewed, about one third completed SSQs both before and after the training, and about one third completed an SSQ after training.

In addition to the data we collected specifically for this research, we reviewed the training records of soldiers from previous OSUT companies who trained on the device. According to the TDT site managers, each Instructor/Operator(I/O) receives formal training on how to identify manifestations or symptoms of simulator sickness as well as appropriate methods to help relieve trainee discomfort. The I/Os are instructed to record any incident of trainee sickness during a TDT training session. This information is recorded on the trainee's individual training jacket or folder and reported to the site manager.

Method

Subjects

The 115 trainees participating in the research were from a One Station Unit Training (OSUT) company located at Fort Knox, Kentucky. The OSUT company consisted of four separate platoons. The OSUT trainees were just beginning their tank driver training using the TDT. All were training to be M1/M1A1 Abrams Armor Crewman, whose Military Occupational Specialty would be 19K10. Nineteen (16.5%) of the trainees were members of the Army National Guard (ARNG), the others were Regular Army (RA). During the data collection period 10% of the trainees became unavailable because of factors such as separation from service or transfer to a different company.

Procedure

TDT training. An OSUT platoon usually trains on the TDT either in the morning (0700-1130 hr) or afternoon (1300-1630 hr). Occasionally, evening sessions are conducted. Training on the TDT is not usually scheduled on consecutive days. Instead, tank driver training is conducted over a period of about two months and is interspersed with other OSUT activities.

When a platoon arrived at the TDT site, the trainees were seated in a classroom and briefed by a Senior I/O on administrative requirements such as safety, conduct of training, and rest areas. This briefing usually lasted 10-15 minutes after which an ARI researcher administered a Background Information Questionnaire.

An ARI researcher described and demonstrated the Postural Stability Test before testing began. After answering questions they had about the postural stability test, the trainees were administered the test by one of three ARI researchers.

The balance test required the trainees to stand on one foot, with eyes closed and their hands crisscrossed over their chest and to maintain this posture for as long as possible up to a maximum of 30 seconds. The score was the amount of time before the raised foot touched or 30 seconds had elapsed. Trainees were told that they could wiggle or scoot their foot to maintain balance, but that jumping or hopping would be scored as a loss of balance, as would touching the floor with the lifted foot. They also were told to put their foot down any time they felt that they were going to lose their balance and fall. Because the posture test was administered more than once to each trainee it was important to insure that each trainee had the same amount of practice. Therefore, if a trainee lost balance before thirty seconds elapsed, he was required to keep trying for a total of thirty seconds.

The TDT has two wings separated by rest rooms and reception, office, and briefing areas. Typically, trainees are assigned as pairs to each of the TDT systems in one wing and assigned one-to-a-system in the other wing. The trainees assigned as pairs alternate training. Upon exiting the system, the trainees were instructed to report to the nearest ARI researcher for a second postural stability test. The trainees would then complete a Physical Status Questionnaire (see APPENDIX D) and either complete an SSQ or be interviewed by an ARI researcher.

M1 field driving training. We collected SSQ, interview, and postural stability data for two of the OSUT company platoons during their first driver training session with M1 tanks. The driving course was paved, undulating, and included a series of obstacles, such as ditches or bumps, over which a tank could pass. The course included a ramp which simulates driving a tank onto a railroad car.

In addition to a turn as tank driver, each trainee rotated through the loader and gunner positions. Based upon the condition of the course and his perception of the trainee's driving skills, the TC could decide to have a trainee bypass one or more of the obstacles and/or the ramp. Upon completing the driving course loop, the trainee would dismount the tank and be given a postural stability test by an ARI researcher and then given an SSQ or be interviewed.

Review of OSUT training records. With the cooperation of the TDT site managers, training data were made available to the ARI staff for six OSUT companies who trained on the TDT. This data consisted of a training folder for each trainee. A cover sheet identified the trainee and noted the specific date(s) on which he completed an M1 TDT training session, the scenario(s) trained, the fuel used and miles driven, the specific system (trainer) used, and a remarks column. Each folder contained a copy of the

trainee's last TDT Student Record and a M1-TDT Instructor Notes form.

A total of 528 individual trainee folders were reviewed for indications of simulator sickness. This review involved checking the cover sheet of each trainee's folder and then reading the enclosed M1-TDT Instructor Notes form. Whenever an indication of trainee sickness was recorded by an I/O, a record was kept to determine the number and percentage of trainees who were reported "sick" by company. "Sick" was operationally defined as any I/O report of trainees experiencing a slight headache or mild dizziness to nausea or vomiting. Also recorded was the training scenario or scenarios during which the incident(s) took place. If there was more than one incident of sickness by a trainee during his TDT session, the number was recorded so as to tabulate the total number of such incidents.

Results

Trainee Background Information

All trainees were male. Their ages ranged from 18 to 35 years with a mean of 21 and a median of 20 years. Height varied from 60 to 79 inches, with a mean and median of 70 inches. Twenty-six percent of the trainees wore glasses.

Analyses of SSQ Total Severity and Subscale Scores

Table 3 displays the breakdown of the number of SSQs administered as a function of whether they were given before (Pre) or after (Post) the training session and by session. For "Session", session 1 is the first time the trainee trained with the TDT, 2 is the second, and "last" is the last session the trainee had on the TDT. "Middle" is the sample taken between the 2nd session and the last. "M1" is the field driving session with the actual M1 tank.

Table 3

SSQ Administration Across Sessions

	Training Session				
	1	2	middle	last	M1
Pre	31	21	26	29	19
Post	62	50	48	63	39

Figure 1 shows the average SSQ Total Severity score and the three subscale scores for the trainees' first, second, "middle", and last sessions on the TDT and the first session of driving the actual M1 in the field.

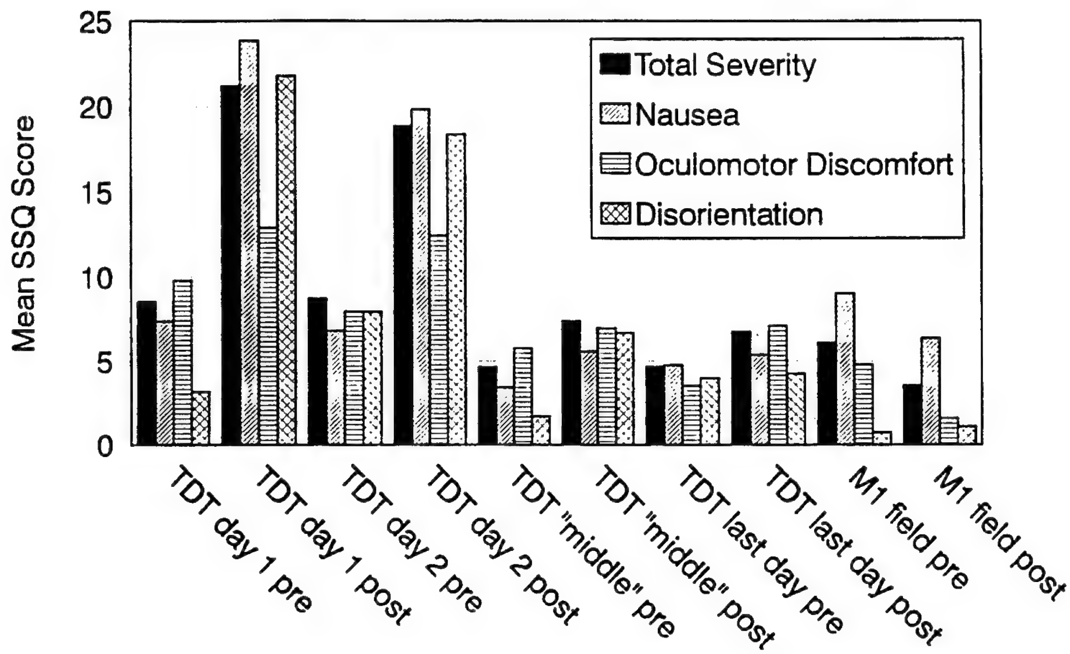

Figure 1. Mean SSQ Total Severity and subscale scores across TDT training sessions.

We conducted a series of Analyses of Variance (ANOVAs) on the SSQ Total Severity scores and the scores for each of the three SSQ subscales. An alpha level of .05 was used for all of these statistical tests.

For the TDT sessions, the Post-session SSQ Total Severity (TS) scores were significantly greater than the Pre-session scores (Table 4). For two of the subscales, Nausea and Disorientation, the Post-session scores were also significantly greater than the Pre-session scores.

Table 4

ANOVAs Comparing Pre-Session Versus Post-Session SSQ TS and Subscale Scores for First Session with TDT

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Nausea					
PRE vs POST	1	5602.1065	5602.1065	9.0503	.0034
Within Groups	91	56328.8408	618.9983		
Total	92	61930.9473			
Oculomotor					
PRE vs POST	1	202.9977	202.9977	.6296	.4296
Within Groups	90	29019.8269	322.4425		
Total	91	29222.8247			
Disorientation					
PRE vs POST	1	7176.6491	7176.6491	7.6140	.0070
Within Groups	91	85772.8846	942.5592		
Total	92	92949.5337			
Total Severity					
PRE vs POST	1	3288.0995	3288.0995	5.4028	.0224
Within Groups	90	54773.0598	608.5896		
Total	91	58061.1592			

The Pre-session TS and subscale scores did not vary significantly as a function of session. Post-session scores did vary significantly as a function of session for Total Severity, Nausea, and Disorientation (Table 5). For these three measures Post-hoc Duncan range tests indicated that scores for the first two sessions were significantly higher than the middle and last sessions. For the Oculomotor Discomfort (Eyestrain) subscale the same pattern was observed. That is, the Post-session scores were higher than Pre-session scores and the scores for the first two sessions were greater than the middle and last, but these differences were not statistically significant.

Table 5

ANOVAs for SSQ Total Severity and Subscale Scores Across Sessions

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Nausea					
Session	3	15732.8434	5244.2811	10.6446	.0000
Within Groups	218	107401.7518	492.6686		
Total	221	123134.5952			
Disorientation					
Session	3	12869.9016	4289.9672	5.7508	.0008
Within Groups	218	162623.9777	745.9815		
Total	221	175493.8794			
Total Severity					
Session	3	9661.8084	3220.6028	6.4204	.0003
Within Groups	217	108851.7719	501.6211		
Total	220	118513.5803			

For both the first session and collapsed across all sessions, there were no significant differences as a function of whether or not the trainees completed an SSQ before the TDT training session. For those trainees who completed an SSQ both before and after the training session, the mean post-session SSQ TS for the first session was 13.58 (SD = 23.16), and the mean across sessions was 10.90 (SD = 20.44). For the trainees who completed an SSQ only after a session, the mean TS score was 23.94 (SD = 28.27) for the first session and 16.09 (SD = 25.29) averaged across sessions.

Repeated measures ANOVAs were conducted to compare the Pre and Post-session SSQ scores for the M1 field driving session. The only significant difference was found for the Oculomotor subscale, $F(1,17) = 5.59$, $p = .03$. The mean Post score (2.11) was actually lower than the mean Pre score (4.79).

Analyses of the first session on the TDT versus the first session of M1 field driving indicated that there were no differences on the Pre scores. For Post scores the TDT was significantly higher than the M1 for the Total Severity and each of the three subscale scores (Table 6).

Table 6

ANOVAs Comparing TDT Session 1 With M1 for SSQ Total Severity and Subscale Scores

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Nausea					
TDT vs M1	1	7323.4301	7323.4301	12.9708	.0005
Within Groups	99	55896.2910	564.6090		
Total	100	63219.7211			
Oculomotor					
TDT vs M1	1	3074.6357	3074.6357	11.6786	.0009
Within Groups	98	25800.6527	263.2720		
Total	99	28875.2884			
Disorientation					
TDT vs M1	1	10265.5371	10265.5371	11.9744	.0008
Within Groups	99	84871.8468	857.2914		
Total	100	95137.3839			
Total severity					
TDT vs M1	1	7424.1976	7424.1976	13.8584	.0003
Within Groups	98	52500.2194	535.7165		
Total	99	59924.4170			

Predicting Simulator Sickness

The background questionnaire administered to the TDT trainees included two items designed to assess individual susceptibility to motion sickness. This section summarizes the responses to those items and lists two-tailed Pearson correlation coefficients among the items and the SSQ scores.

The question "Have you ever experienced motion sickness (such as in a car or bus, on a plane or train, on an amusement park ride, seasickness, etc)?" was answered "yes" by 13 (22%) of the 60 trainees for which we have post session 1 SSQ scores.

Table 7 presents the frequency distribution of the trainees' responses to the question "How susceptible are you to motion sickness?". There were five response categories as shown in the table. The responses are from the 60 trainees for which we have post session 1 SSQ scores.

Table 7

Self-Rating of Susceptibility to Motion Sickness

Response	Response Frequency
extremely	0 (0.0 %)
very	2 (3.3 %)
moderately	5 (8.3 %)
minimally	27 (45.0 %)
not at all	26 (43.3 %)

Analyses of correlations, Table 8, revealed that trainees who indicated that they had ever been motion sick prior to training on the TDT, or rated themselves as susceptible to motion sickness, were more likely to report simulator sickness. (For these analyses responses to the "Ever motion sick" question were coded 1 for yes and 0 for no. For self-rating of susceptibility, integers were assigned to the response categories such that a higher integer was associated with a higher level of susceptibility). In addition, there were significant positive correlations between trainees' Pre and Post TS and Oculomotor scores. Finally, Post TS scores for session 1 were positively correlated with Post TS scores for session 2, that is, trainees who experienced simulator sickness during session 1 were more likely to experience sickness on session 2 (r=.75, n=22, p <.0001). No significant correlations were found between SSQ Total Severity scores and trainee height, age, and whether or not the trainee wore glasses.

TABLE 8

Correlations Between Pre-Session 1 Responses and Symptoms and Post-Session 1 Symptoms

PREDICTOR	N	POST TS	POST N	POST D	POST O
Ever Motion Sick	60	.50***	.48***	.48***	.46***
Motion Sickness Suscep tibility	60	.43***	.37**	.44***	.38**
PRE-TS	30	.38*	.25	.29	.50*
PRE-N	30	.25	.12	.19	.36*
PRE-D	30	.24	.23	.23	.22
PRE-O	30	.42*	.29	.31	.57**

* P<.05 TS = Total Severity D = Disorientation
** P<.01 N = Nausea
*** P<.001 O = Oculomotor Discomfort

Individual SSQ Symptoms

APPENDIX E presents the severity ratings for each individual symptom as a function of session. The Pre scores for the TDT sessions indicate that many of the trainees are not symptom free when they arrive at the TDT site. Examination of individual symptoms reveal that almost half of the trainees report suffering from drowsiness or fatigue. (Trainees indicated this was from lack of sleep.) In addition, several of the trainees had symptoms resulting from colds or flu. In contrast, the Pre scores for the field training primarily reflect "sweating", which could be expected outdoors in July.

For the SSQs administered after the TDT training sessions, symptoms related to stomach discomfort predominate in the first two sessions, then decline. Symptoms related to eyestrain remain at about the same level across sessions.

For field training, there was no indication that driving an actual M1 tank produced any symptoms. Some of the trainees mentioned that when they were in the gunner's position they experienced some nausea which may have persisted when they rotated for their turn as driver.

Table 9 provides a very rough comparison of our results with that of an Israeli study (Lerman et. al, 1992) of simulator sickness. For five of six comparable symptoms, the M1 TDT incidence is better or no worse than the Israeli tank driving trainer. Only nausea is worse with the M1 TDT.

Table 9

Comparison of Simulator Sickness for Two Tank Driving Simulators

	Trainees reporting the symptoms (%)							
	Driver Trainer				Tank			
	Any Severity		Moderate to High Severity		Any Severity		Moderate to High	
Symptoms	TDT	ISIM	TDT	ISIM	M1	ITNK	M1	ITNK
Sweating	45.9	50.0	19.7	32.1	33.3	70.0	12.8	40.1
Dizziness	15.3	39.3	3.4	21.4	2.6	10.0	0.0	6.7
Nausea	35.5	29.6	16.1	11.1	5.1	20.0	0.0	3.3
Confusion	8.4	22.2	1.7	7.4	2.6	13.3	0.0	0.0
Drowsiness	27.8	35.7	1.6	13.3	2.6	40.0	0.0	13.3
Increased Salivation	5.0	14.3	0.0	3.5	0.0	6.7	0.0	0.0

TDT = M1 TDT   ISIM = Israeli Driver Trainer

M1 = M1 tank   ITNK = Israeli tank

Trainee Interviews

Table 10 presents the responses to five of the interview questions as a function of session. For each, the table entry indicates the percentage of the respondents who indicated some problem in the area addressed by that question. For example, the first question "How do you feel?" indicates the percentage of respondents who indicated that they did not feel well, that is,

they gave some response other than "fine, good, great, ok, all right". For the first session slightly less than 20% of the trainees who were interviewed indicated that they were not feeling well. Conversely, about 80% responded with, or something similar to, "fine" or "ok". Note that the primary purpose of this question was to determine that the subsequent focussed questions were not somehow inducing the trainees to exaggerate the extent of simulator sickness or to report sickness when none actually had occurred.

Table 10

Responses to Interview Questions by Session

	Session			
	1	2	"middle"	last
N	36	20	26	34
% not feeling well	19.4	25	7.7	20.6
% reporting discomfort while in the simulator	36.1	40	26.9	20.6
% reporting interference with training	13.9	5	7.6	11.7
% did not enjoy session	0	5	3.8	0

To the question "Did you feel any discomfort while in the simulator?" 36% responded yes for session 1 and 40% for session 2.

For session 1, of the 14% who responded that the discomfort they experienced was bad enough to interfere with training, all reported that their TDT training that day was interrupted or terminated because of simulator sickness. Those trainees who experienced some discomfort, but not to the extent that an exercise was interrupted, stated that simulator sickness did not interfere with their training.

For the first session, 100% of the trainees, even those who reported sickness, responded that they enjoyed training with the TDT. For the second session, 5% reported that they did not enjoy the training session. We suspect that for those trainees who experienced discomfort during both of their first two sessions

with the TDT the negative aspects of the experience outweighed the positive.

Table 11 presents the trainees' severity ratings for stomach discomfort, dizziness, eye strain, and claustrophobia. No symptom was rated worse than "moderate" in the first session and, with the exception of eyestrain, no symptom was rated worse than "mild" in the second session.

Table 11

Trainees' Interview Ratings of Key Dimensions of Simulator Sickness Across Sessions

Symptom	Session			
	1	2	"Middle"	Last
	n=36	n=20	n=26	n=34
stomach				
none	28 (77.8%)	15 (75.0%)	22 (84.6%)	31 (91.2%)
mild	5 (13.9%)	5 (25.0%)	4 (15.4%)	3 (8.8%)
moderate	3 (8.3%)	0	0	0
severe	0	0	0	0
dizziness				
none	32 (88.9%)	18 (90.0%)	25 (96.2%)	31 (91.2%)
mild	3 (8.3%)	2 (10.0%)	1 (3.8%)	3 (8.8%)
moderate	1 (2.8%)	0	0	0
severe	0	0	0	0
eyestrain				
none	33 (91.7%)	16 (80.0%)	20 (76.9%)	29 (85.3%)
mild	2 (5.6%)	3 (15.0%)	6 (23.1%)	4 (11.8%)
moderate	1 (2.8%)	1 (5.0%)	0	1 (2.9%)
severe	0	0	0	0
claustro-phobia				
none	35 (97.2%)	20 (100%)	26 (100%)	32 (94.1%)
mild	1 (2.8%)	0	0	2 (5.9%)
moderate	0	0	0	0
severe	0	0	0	0

Finally, Table 12 presents the trainees' ratings across sessions of the temperature in the TDT.

Table 12

Trainees' Ratings of Temperature Inside the TDT Across Sessions

	Session							
	1		2		Middle		Last	
	(n=36)		(n=20)		(n=26)		(n=34)	
hot	1	(2.8%)	2	(10.0%)	0		0	
warm	9	(25.0%)	4	(20.0%)	4	(15.4%)	3	(8.8%)
about right	17	(47.2%)	9	(45.0%)	12	(46.2%)	14	(41.2%)
cool	9	(25.0%)	5	(25.0%)	9	(34.6%)	16	(47.1%)
cold	0		0		1	(3.8%)	1	(2.9%)

Most of the trainees rated the temperature as "about right" or "cool". We believe that some of the trainees who experience simulator sickness, especially those who sweat profusely, would rate the temperature as "hot" or "warm" regardless of the actual temperature inside the TDT.

Postural Stability

A repeated measures ANOVA comparing PRE and POST postural stability scores for session 1 was not significant. For the balance on one foot test the means and standard deviations (shown in parentheses) were: 21.16 (10.04) seconds for PRE and 22.01 (10.62) seconds for POST. The PRE and POST balance scores were significantly correlated (r=27, n=98, p=.007). Correlations were not significant between the POST posture test and the TS score or any of the three subscales.

Review of OSUT Training Records

As shown in Table 13, the percentage of simulator sickness reported in training records ranged from 19 to 32.1. Note that this represents the percentage of trainees who were symptomatic one or more times over the entire course of training. For the six OSUT companies reviewed, the average percentage of trainees reported sick was 24.6. The number of reported incidents of such sickness during training was nearly twice the number of trainees who were reported sick. On the average, therefore, most trainees

who were reported sick experienced more than one incident of discomfort while training on the TDT. Unfortunately, the I/O records were too general to define the severity of the trainee's sickness, i.e., simulator discomfort versus simulator sickness. Moreover, it was not clear whether the I/Os reported all cases of simulator sickness, especially when a trainee was returned to training following a 15-30 minute period to "recover" from his sickness. (In I/O interviews, approximately 25% were not aware of the requirement to complete this document).

Table 13

I/O Records of Incidence of Simulator Sickness by Company

Unit	Number of Students	Number Reported Sick	Number of Reported Incidents	Percent Sick
C Company	100	19	39	19.0
D Company	103	24	35	23.3
B Company	51	16	51	31.4
F Company	71	19	33	26.8
G Company	150	35	60	23.3
F Company	53	17	34	32.1
Total	528	130	252	24.6

Table 14 presents the incidence of simulator sickness broken down by individual scenarios. (Approximately 100 different training scenarios are available for the TDT. Training managers decide which of the scenarios to use in the TDT POI). The majority (80.2%) of the incidents of simulator sickness reported by the I/Os occurred during training on five (#20110, 10210, 13970, 10110, and 10111) of the 22 TDT scenarios used in the POI. Four of these five scenarios required driving a tank in the motor pool, the other involved driving on steep hills. Analyzed in terms of the chronological order in which the scenarios are presented during training, all five occur during the trainee's first three hours on the TDT. The scenarios vary along a number of dimensions such as task region, visibility, time of day, and hatch mode. The right-most column in Table 14 is based on one of the questions from the I/O interviews. The column presents for each scenario the percentage of the I/Os interviewed who identified that scenario as among the most sickness-inducing.

Table 14

I/O Records and I/O Interview Estimates of Incidence of Simulator Sickness by Scenario

Scenario Number	Task Region	Visibility	Time of Day	Hatch	Total # of Sim sick Incidents	% I/Os identifying as problem
20110	Motor Pool	Summer/Haze	Day/Full	Open/Closed	48	19
10210	Motor Pool	Summer/Clear	Day/Full	Open	67	81
13970	Steep Hills	Summer/Haze	Day/Full	Closed	27	33
10110	Motor Pool	Summer/Clear	Day/Full	Open	46	81
11610	Motor Pool	Snow/Clear	Day/Full	Closed	7	0
10111	Motor Pool	Summer/Clear	Day/Full	Closed	14	43
11251	Urban Area	Snow/clear	Day/Full BOM	Closed	6	0
10211	Motor Pool	Summer/Clear	Ngt/Bright BOM	Open	4	33
13851	Urban Area	Summer/Clear	Ngt/Bright H	Closed	3	0
13081	Rolling Hills	Summer/Clear	Ngt/Bright BOM	Open	2	0
14280	Rolling Hills	Summer/Fog	Day/50%	Open	1	0
12371	Steep Hills	Summer/Haze	Night/Dark V	Closed	5	0
14181	Rolling Hills	Summer/Haze	Day/50%	Open	2	0
12660	Mountain Terr	Summer/Haze	Day/Full	Open	1	0
12661	Mountain Terr	Summer/Clear	Night/Dark H	Closed	1	0
12120	Obstacles	Summer/Clear	Day/Full	Open	7	0
13681	Steep Hills	Summer/Clear	Night/Dark V	Closed	4	0
13381	Steep Hills	Summer/Haze	Day/50%	Open	1	0
13380	Steep Hills	Summer/Clear	Night/Dark H	Open	2	0
14420	Obstacles	Summer/Clear	Night/Dark V	Closed	2	0
14880	Rolling Hills	Summer/Clear	Day/Full	Closed	1	0
20290	Plains	Summer/Clear	Day/full	Open/Closed	1	0
					252	

Note: H=headlights, BOM=Blackout Markers, V=Night Vision Viewer

I/O Interviews

Detailed results of the I/O interviews are presented in APPENDIX F. Sixty-two percent of the I/Os stated that simulator sickness is not a problem in the TDT. Many I/Os noted that most incidents of sickness occur during the first training sessions, many of the trainees who get sick initially never get sick again. Many I/Os emphasized that before the trainees set foot in the TDT facility the trainees hear rumors that the device will make them vomit. These rumors may become self-fulfilling prophecies as rumor-induced tension makes some of the trainees more susceptible to simulator sickness.

Two scenarios, #10210 and #10110, were identified as especially nauseagenic. At the time of the interviews, these were the second and fourth training scenarios presented to a driver trainee, respectively. Scenario #10110 involves a slalom course in which a trainee must drive the tank around and through a series of pylons. Scenario #10210 involves responding to a ground guide who directs the trainee around a motor pool and through various maneuvers such as parking.

Test Driving the TDT

Three ARI researchers test-drove the TDT at the developing contractor's facility (details are presented in APPENDIX G). The researchers concluded that there were no obvious errors in the design or construction of the TDT. Motion and visuals seemed to be well synchronized. Perusal of the technical specifications of the TDT indicated that the specifications were well within simulation industry standards for factors such as asynchrony of visual and motion cues. ARI researchers did not attempt to verify that the TDT is functioning within those specifications.
An engineer cautioned the researchers not to stare at any one of the display screens but rather to frequently shift their area of focus across the three different display screens and the instrument panels. (I/Os at the TDT training site convey a similar warning to the trainees). Two of the three researchers did not experience simulator sickness. These two drove the TDT with the motion platform turned on and with motion off. At worst, they experienced mild "stomach awareness" comparable to what one might experience during the takeoff of a commercial airliner. In addition, there was a barely noticeable sensation involving focussing the eyes. The third researcher intentionally ignored the warning not to stare at the screens. In addition, he performed driving maneuvers, for example rapid pivoting, which would be expected to produce simulator sickness. He experienced a sudden onset of sweating, eyestrain, and nausea, of which the later persisted for over an hour after leaving the simulator. (This same researcher drove an actual M1 tank months after his one session with the TDT. Despite having experienced simulator sickness in the TDT and the considerable length of time that had

passed he felt that there was significant transfer of training from his session on the TDT to M1 driving.)

Each of the researchers noticed that during the times when no computer generated display was being presented on the TDT displays, while a scenario was being loaded for example, there was an odd visual phenomenon involving eye focus. Reflections on the display screens seemed to cause an uncomfortable sensation as focal length shifted. Obviously there is no need for a trainee to look at the screens when a training scenario is not being presented but doing so may produce simulator sickness.

The researchers concluded that there were no obvious errors in the design or construction of the TDT. Motion and visuals seemed to be very well synchronized. Perusal of the technical specifications of the TDT indicated that the specifications were well within simulation industry standards for factors such as asynchrony of visual and motion cues. ARI researchers did not attempt to verify that the TDT is functioning within those specifications.

Discussion

Simulator Sickness Questionnaires administered to trainees, interviews of trainees and I/Os, and I/O records of simulator sickness all indicate the same pattern: although the majority of TDT trainees report few or no symptoms of simulator sickness, some trainees experience significant levels of discomfort during TDT training. The discomfort is significant in both the statistical sense and the sense that training is compromised.

Clearly, at the time we collected data, TDT training produced simulator sickness in some trainees. The SSQ Total Severity scores derived after the initial TDT training are significantly higher than the before-training scores and are significantly higher than the after scores for the initial M1 driving session. In interviews, about 20% of the trainees indicated that they were not feeling well following their first TDT session, and about 14% indicated that the discomfort was severe enough to interfere with training. I/O records indicate that about 25% of the trainees experience discomfort, to the extent that it merits recording, at least once during the entire TDT POI. Both questionnaire and interview data indicated that problems related to nausea were more prevalent than problems related to vision or the sense of balance. For the initial TDT training session, about 6% of the trainees who were administered the SSQ indicated that they experienced nausea severe enough to result in vomiting.

In regard to our findings of the incidence and severity of simulator sickness during the initial TDT training session

several points can be made: Most trainees reported little or no discomfort from training with the TDT. Almost all trainees, even the ones reporting simulator sickness, stated that they enjoy training with the TDT. In general, the individuals most susceptible to simulator sickness can be identified by simple means before TDT training. We found no evidence that training with the TDT resulted in changes in postural stability. It is likely that our tests of postural stability were not very sensitive to changes in the sense of balance. Nevertheless, we can conclude that even those trainees reporting nausea and dizziness are not suffering a severe loss of sense of balance following training with the TDT.

The symptoms, incidence, and severity of simulator sickness observed with the TDT appeared no worse than those reported for a roughly comparable Israeli tank driver trainer. Given the nature of the tasks to be trained (driving over rough terrain, for example) some simulator sickness should be expected. We do not believe that the TDT has any unique problems of simulator sickness in comparison with other training simulators. Nevertheless, we identified some changes to the ways that the TDT is used that could potentially reduce the incidence and severity of TDT simulator sickness. These recommendations, presented in the next section, primarily address the treatment of trainees before, during, and after TDT training and the selection and use of training scenarios.

SSQ, I/O interviews, and inspection of I/O records indicate that simulator sickness decreases subsequent to the initial TDT session. Several factors may be related to the decrease in simulator sickness across sessions. The trainees may perceptually adapt to the TDT visual and movement displays. They may learn to avoid actions, certain head movements for example, that produce simulator sickness. In addition, we can not rule out that the scenarios encountered later in the POI may be less nauseagenic. For whatever reason, simulator sickness declines significantly across training sessions with the TDT.

It is our opinion that there are three primary reasons that some individuals experience simulator sickness in the TDT. First, any driver trainer can produce simulator sickness. Drosdol and Panick (1985) concluded that for driving simulators, however complex, the vehicle model can only approximate the dynamic behavior of the real vehicle due to the restricted movement range. Most simulators are limited in that they must be physically anchored in the real world, and can move at most only a few feet in any direction. Motion in any direction can be sustained for only a brief time. The motion system must therefore use a variety of "tricks," such as using tilt to substitute for sustained forward (horizontal) acceleration, and "sub-threshold" return of the simulator to its neutral or resting position. Motion in the simulator cannot be exactly the same as that in the

actual vehicle. We believe that this inconsistency between the visual and motion cues forms part of the basis for the simulator sickness. A variety of other individual factors (e.g., susceptibility to motion sickness), simulator characteristics (visual-motion lag, field of view), and task characteristics (e.g., type of movement required) may affect the severity of the problem, but the root cause is inherent in the nature of the simulators themselves.

Second, the TDT has a very powerful motion platform which, in the opinion of the authors, is capable of producing "classic" motion sickness. Even if the visual and motion cues could be synchronized perfectly, or the visual display was turned off completely, driving over some terrain at certain speeds will produce movement patterns which will result in motion sickness in some trainees.

Third, anecdotal reports indicate that the TDT visual display will produce simulator sickness symptoms related to eyestrain if the trainee stares at one of the three terrain displays. Most trainees can and do avoid eyestrain by shifting their focus from display to display and to the gauges and controls in the interior of the driver's compartment mock-up.

For field training, there was no indication that driving an actual M1 tank produced any symptoms. Some of the trainees mentioned that when they were in the gunner's position they experienced some nausea which may have persisted when they rotated for their turn as driver.

Examination of the ratings for the individual symptoms which make up the oculomotor discomfort subscale score revealed that general discomfort, fatigue, and headache ratings were lower after driving the M1. Interviews with the trainees indicated that most of them seemed to greatly enjoy their first field driving experience, which may account for why the symptom ratings were lower after the trainees had driven the M1 than the ratings obtained while the trainees were waiting for their turn to drive.

The remainder of this discussion section addresses issues of measuring simulator sickness. One of the goals of our research was to address a question that frequently arises in investigating simulator sickness: Does the procedure of measuring simulator sickness itself somehow increase the likelihood that trainees will experience discomfort? It could be argued that showing the trainees a list of symptoms before they enter the TDT could somehow make them more susceptible to experiencing those symptoms. We do not think this argument holds for our TDT data collection. There were no significant difference in post-training SSQ Total Severity scores between those trainees who filled out an SSQ before training and those who did not. I/O records of the number of incidents of simulator sickness for the company we

observed matched the average number of incidents of the companies that trained previous to our data collection effort. In addition, whether ARI data collectors are there or not, TDT trainees: hear rumors that the TDT will make them vomit, are given a "motion sickness bag" to carry into the TDT, and are given instructions by the I/Os on how to recognize and report simulator sickness. Clearly, valuable information was gained by presenting the SSQ before training. For example, we determined that when the trainees arrive at the TDT many of them are tired and sleepy, factors which increase susceptibility to simulator sickness. In addition, some of the trainees are already "sick", due to colds or flu.

During the course of the data collection we frequently observed trainees with pronounced pallor, that is extreme or abnormal paleness, and we occasionally observed trainees vomiting into plastic motion sickness bags immediately upon exiting the TDT cab. Of the hundreds of SSQs and interviews we administered in only one case did we doubt the veracity of the responses given by a trainee. During subsequent questioning the trainee stated that he had been confused about the rating scale. We did not use those SSQ responses in our analyses.

I/O records of simulator sickness proved valuable in several ways. Records of simulator sickness provide the user with a quantitative benchmark by which such sickness can be judged to exist in the TDT. They also provide a baseline by which the OSUT company under observation can be compared. That is, is the reported number of incidents of simulator sickness for the company the same or different from previous OSUT companies that trained on the TDT? Lastly, by providing a means to identify the most problematic training scenarios, I/O records enable the user to take a closer look at those scenarios and implement appropriate actions to help reduce or alleviate the simulator sickness problem.

Recommendations

We presented the following recommendations to the CDR, 1st Armor Training Brigade. Each recommendation, which is underlined, is followed by a brief rationale.

1. <u>Consider using the free play session to "inoculate" the trainee against simulator sickness: make the first session brief and avoid elements that tend to produce sickness</u>.

<u>Rationale</u>: The free play period, the trainee's first experience in the TDT, provides a means for the trainee to learn the basic methods of controlling the direction and speed of tank movement. However, the free play period currently includes several elements that may cause simulator sickness and should be omitted:

Any movement not under control of trainee:
- simulation of loss of steering while moving
- I/O controlling movement
- replay of the exercise

Catastrophic collisions

Sliding at a high speed

(McCauley and Sharkey (1992) suggested that longer exposure times will result in an increased incidence of sickness. Kolasinski (1995) concluded that depiction of movement not under control of the trainee is more likely to produce simulator sickness. Catastrophic collisions may be nauseagenic (personal experience of an ARI researcher) and may be analogous to flight simulator "freeze" situations which Kennedy, et. al (1988) recommended avoiding during initial sessions).

2. Avoid prolonged driving on slalom courses.

Rationale: In the real-world, slalom courses can provide an efficient way to practice making turns. However, in the TDT the slalom courses may be especially likely to cause nausea. If there is not a need to drive slalom courses in actual combat then consider modifying the TDT slalom scenarios or modifying how those scenarios are used. (Sharkey and McCauley (1992) reported that flying a series of "S-turns" in a flight simulator resulted in simulator sickness in all of the pilots participating in an experiment. Frank and Casali (1986) identified rapid driving through tight curves and slow driving in large angle turns as maneuvers which have been found to be particularly provocative in driving simulators.)

3. Provide a substitute helmet that is adjustable and cooler than the CVC helmet.

Rationale: For some trainees the CVC helmet does not fit properly and contributes to the sensation of heat stress.(TDT managers were already working to solve this problem by the time our recommendations were presented to them.)

4. For the five scenarios with the highest incidence of simulator sickness consider: replacement, modification, modification of how the scenarios are used, or presentation later in the POI when trainees are less likely to experience simulator sickness.

Rationale: Five of the (22) scenarios now in use have higher incidences of simulator sickness than the other scenarios. It may be that these scenarios have a higher incidence of simulator sickness because they are among the first the trainees encounter in the TDT POI. However, each has characteristics which are or

could be nauseagenic. For example, one of the scenarios involves driving up a mountain road such that one side of the visual display is filled almost entirely by the mountain side and the other side of the visual display is open space. A rapid dip is encountered at the top, producing a roller-coaster effect. (Frank and Casali (1986) identified sudden changes in grade as a maneuver which has been found to be particularly provocative in driving simulators.)

5. <u>Decrease stressors affecting trainees on their first TDT training session</u>.

<u>Rationale</u>: For field training it is to be expected, and sometimes wanted, that trainees will be fatigued or otherwise stressed during training. However, stress may be <u>uniquely counterproductive</u> during the first session on the TDT. In addition to lack of sleep, the trainees are under additional stress in that they hear rumors that the TDT will make them vomit. (Kennedy, Hettinger, and Lilienthal (1988) stated that fatigue, sleep loss, hangover, upset stomach, periods of emotional stress, or colds may increase susceptibility to simulator sickness).

6. <u>When a trainee becomes ill he should be instructed to avoid watching the monitor at the I/O station. In addition, until recovered, the trainee should not be required to drive any (real-world) vehicle</u>.

<u>Rationale</u>: Monitors at the I/O station depict views somewhat similar to what the trainee in the TDT is observing. Often a trainee that has just exited the TDT will sit with the I/O and watch as another trainee drives. Watching motion depiction on the monitors can delay the recovery from simulator sickness or reinstate symptoms (personal experience of an ARI researcher). Simulator sickness can persist for hours. In a very few extreme cases, simulator sickness may be severe enough to pose a safety problem in subsequent real-world activities (Crowley, 1987).

7. <u>Trainees (and I/Os) should not be punished (or rewarded) for reporting simulator sickness</u>.

<u>Rationale</u>: I/O records of trainee reports of simulator sickness provide valuable and accessible data for addressing simulator sickness issues in the operation of the TDT and for the design of future training devices. Any policies that discourage accurate reporting will jeopardize this important source of information. That some I/Os might report a higher incidence of simulator sickness than others does not necessarily indicate that the performance of the I/O is the cause of the higher than average rate. Because each I/O almost always works with the same TDT system each day it would be difficult to determine whether the

I/O or the system is the cause of the rate of simulator sickness observed. In addition, a higher rate may indicate that an I/O is more sensitive in detecting, or more conscientious in reporting, simulator sickness.

8. Establish a procedure for dealing with cases of severe simulator sickness.

Rationale: Some individuals are more susceptible to simulator sickness than others. Given that large numbers of individuals who train at or visit the TDT site there may eventually be a case of extreme simulator sickness which may require extracting the individual from the simulator cab.

Future Research

The recommendations listed above are being implemented by the CDR, 1st Armored Training Brigade, Fort Knox, KY. Some of the recommendations, such as addressing the problem of having only one size helmet at each TDT system, had already been recognized and acted upon by the time our recommendations were presented. Other recommendations, such as experimenting with the order in which scenarios are presented as a means of reducing simulator sickness, will obviously take some time to implement. We anticipate that after the recommendations have been implemented we will collect additional data to see if there has been a reduction in simulator sickness and to determine if additional research is warranted.

At least three additional lines of research warrant consideration. One involves the role of motion platforms in simulator sickness. Another involves the use of anti-motion sickness medication as a means of dealing with simulator sickness. A third involves manipulation of the width of the field of view of the visual displays.

There are conflicting accounts concerning the role of motion platforms in simulator sickness. Peterson and Johnson (1989) reported that the I/Os and test personnel who served in an on-site evaluation of the TDT felt that using the TDT without the motion system operating would result in severe simulator sickness. They reported that a driver became nauseated while driving the TDT with the motion platform turned off and that the nausea persisted for over 5 hours. In contrast, TDT I/Os are now told that temporarily turning off the motion system is one way of dealing with simulator sickness. Research to examine the role of motion platforms in simulator sickness could help guide conduct of training with the TDT and, given the expense of motion platforms, provide valuable information to guide the design and acquisition of future training devices.

Regan and Ramsey (1994) reported that administration of an anti-motion sickness drug significantly reduced nausea, stomach awareness, headaches, and eyestrain in subjects in a virtual reality experiment. However, it was not determined if the drug affected performance. Casali (1986) noted that anti-motion sickness drugs may degrade motor control and attentional skills. After the performance measurement system is incorporated, the TDT could be used in research to examine the effects of anti-motion sickness drugs on simulator sickness and driving performance.

One of the recommendations presented by Kennedy et. al (1988) for alleviating simulator sickness was to decrease the field of view during simulator sessions that may be particularly nauseagenic (initial sessions for example). The TDT already has a capability to manipulate width of field of view in that presentation of scenarios in the TDT's closed hatch mode involves a narrower field of view than the open hatch mode. The decrease, if any, in simulator sickness that might be obtained by using the closed hatch mode in initial training sessions or for particularly nauseagenic exercises must be balanced with the impact such a manipulation might have on the effectiveness of the program of instruction.

Summary and Conclusions

The symptoms, incidence, and severity of simulator sickness observed with the TDT appeared no worse than those reported for a roughly comparable Israeli tank driver trainer. Given the nature of the tasks to be trained (driving over rough terrain, for example) some simulator sickness should be expected. We do not believe that the TDT has any unique problems of simulator sickness in comparison with other training simulators.

However, simulator sickness does degrade training effectiveness for some trainees. In addition, the threat of simulator sickness increases the workload of the I/Os and training program managers.

ARI developed a set of recommendations which may provide a cost-effective way to reduce simulator sickness in the TDT. In addition, we outlined areas of research which may benefit not only the TDT but also the design of other training simulators.

Simulator sickness is part of the "cost of doing business" in using flight and driver training simulators. A plan for management of simulator sickness should be a part of any training program which involves simulators which depict self-motion of the trainee.

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APPENDIX A

Description of the M1 Tank Driver Trainer

The M1 TDT is depicted below in Figure A-1. As described in the Instructor Utilization Handbook for the M1 Tank Driver Trainer (General Electric Company, 1992), the M1 TDT consists of two trainer subsystems and one computer subsystem. The major components of the M1 TDT are: two crew compartments (1) with access platforms and stairs (5), two motion platforms (6) and control consoles (2), two Instructor/Operator (I/O) Consoles (3), and one computer system (4). The crew compartments are replicas of the interior of the M1 tank driver's compartment. All the switches and controls the driver needs to operate the tank are present and functioning. Some replicated controls which are not needed for normal tank operation are included but are nonfunctional. The driver views computer generated imagery through vision blocks, the AN/VVS-2 night vision device, or through the open hatch. The I/O views the same imagery at the I/O Console (IOC)on 19-in high-resolution color monitors.

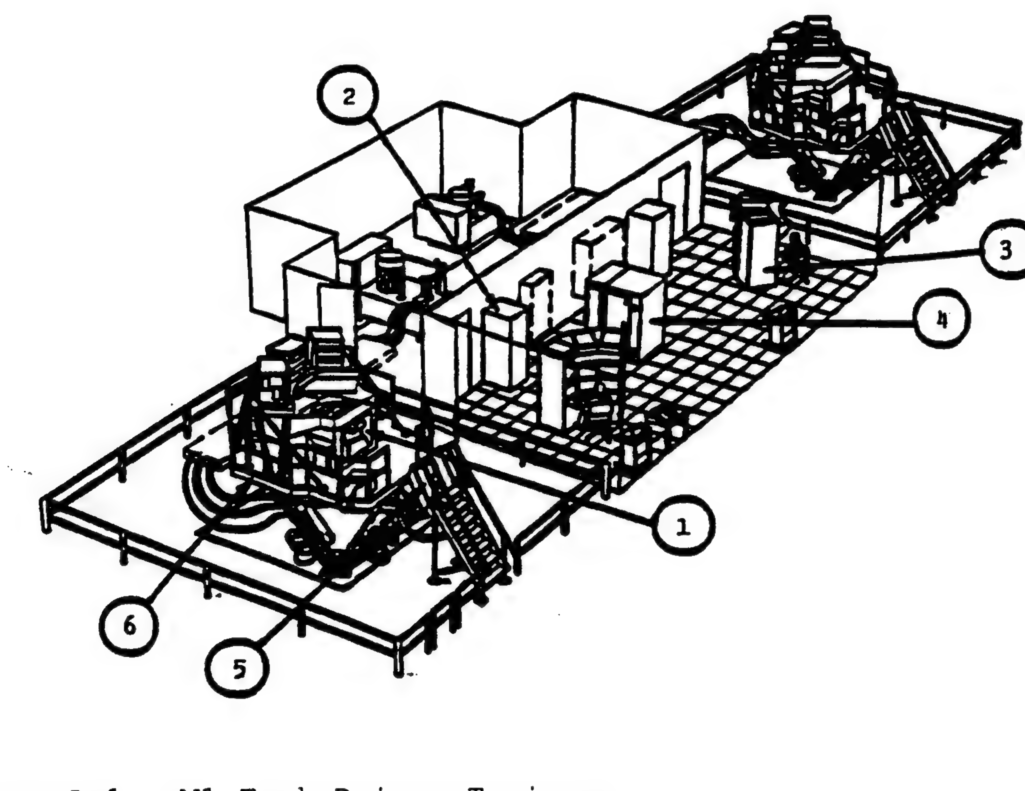

Figure A-1. M1 Tank Driver Trainer

The motion control console (2) provides controls for remote startup, maintenance, normal and emergency shutdown of the motion platform (6). The motion platform provides the simulated motion of a moving M1 tank. It simulates motion associated with acceleration, deceleration, braking, collisions, skids, turns, and the suspension system. Six degrees of motion (pitch, roll, yaw, heave, surge, and sway) provide the realistic "feel" (sensory inputs) when traversing terrain. Six hydraulic actuator arms support the platform and provide the motion. The maximum delay between an input and system response is 105 ms. The maximum delay between the motion platform response and visual response is 35 ms. For safety, a fence surrounds the entire motion platform area. Beneath the platform there is a rotating beacon which activates when the motion platform is in use. Should the motion platform freeze in the elevated position, a rope ladder, located by the driver's compartment door, provides an emergency exit.

The Instructor/Operator Console (IOC), see Figure A-2, provides the controls and indicators needed to monitor and control M1 TDT operation. The IOC provides the I/O with three functions: exercise control, performance monitoring, and exercise critique.

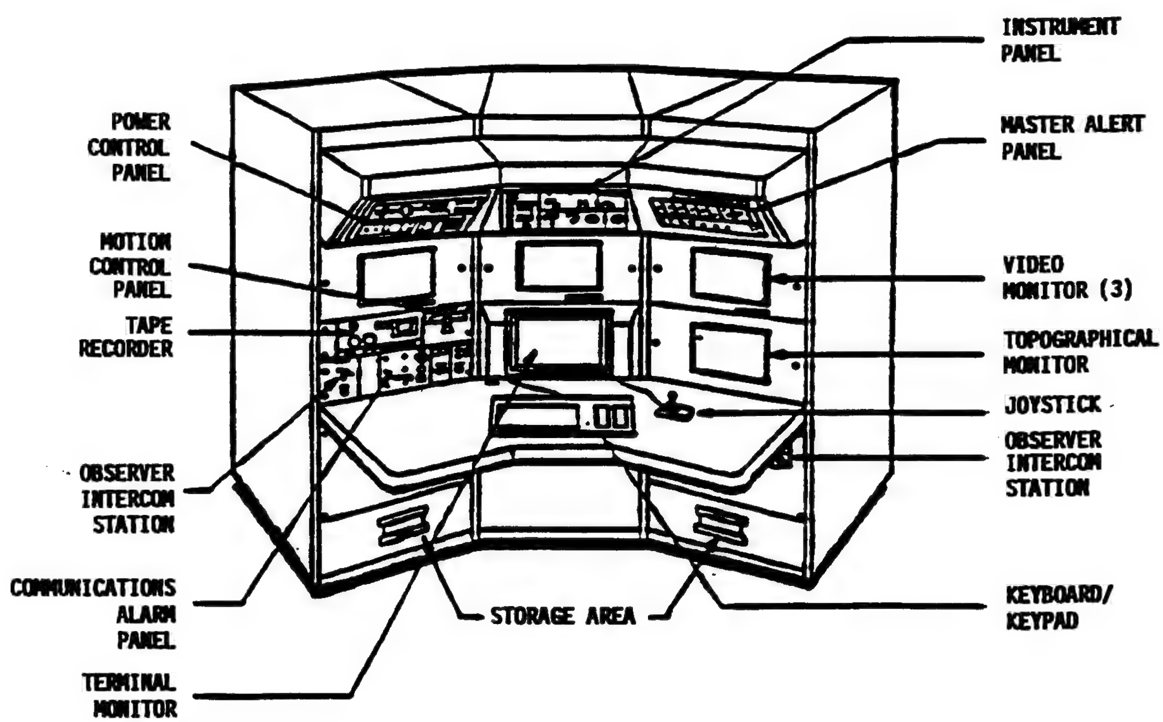

Figure A-2. Instructor/Operator Console (IOC)

From the IOC, the I/O has complete control of the training scenarios. By the press of a key, the I/O can control the trainer using a joystick. Own vehicle location is plotted in realtime on a topographical map (TOPO). The TOPO map is displayed on a high resolution color monitor at the IOC and is updated continually as the driver moves through the database. The system automatically evaluates the trainee and provides training records. Hard copy records can be printed on the system printer by the press of a key. Individual trainee historical records are stored automatically and are also available as hard copies. The system generates visual scenes and aural cues (sound effects) using a PT 2000 Image Generator (IG). The IG creates terrain that is visible in the crew compartment and at the IOC. The terrain database represents a gaming area of 10 nautical miles (11.4 miles) wide by 15 nautical miles (17.1 miles) long. The system creates moving models of the own vehicle, civilian and military vehicles (friend or foe). A human figure dressed in Battle Dress Uniform (BDU) functions as a ground guide or as the platoon leader. It has movable hands and arms. This feature allows it to give hand and arm signals. The artificial soldier reproduces most of the hand and arm signals used in both tactical and administrative settings. Other images provided are artillery explosions, own vehicle main gun fire and a gun flash, and enemy fire signatures (cannon and missile). After the gun fires, the driver hears the sound of the breech opening and the spent casing hitting the turret floor. The system also provides host computer input/output support and furnishes the images and scoring computations for two complete stations.

Entry to the crew compartment is by an access stairway and over a moveable entrance platform. An interlock prevents the motion platform from activating when the entrance platform is in the lowered position. The platform must be in the elevated position for the motion platform to function. If an emergency stop or an abort occurs, the platform automatically descends to the exit (down) position. Other interlocks that prevent platform actuation are at the platform gate (at the foot of the access stairway), the crew compartment rear door, and the driver's hatch shroud (an emergency exit).

For a more detailed description of the M1 TDT, refer to the Operator's Manual [Department of the Army (1992, September). Operator's manual for trainer M1 Tank Driver [M1-TDT] (TM 9-6930-701-10). Washington, DC: Author.] This technical manual is the primary source document for operating the M1 TDT.

APPENDIX B

Modified Simulator Sickness Questionnaire (SSQ)

NAME: ________________ SSN: ____________ Unit: ______
(Last, MI, First) (Last 4 Digits) (Plt)

Today's Date ____ - ____ - ____ Time of Day __________
(Month) (Day) (Year) (Military)

Please CIRCLE the severity of symptoms that apply to you **now.**

1.	General Discomfort	None	Slight	Moderate	Severe
2.	Fatigue	None	Slight	Moderate	Severe
3.	Headache	None	Slight	Moderate	Severe
4.	Eye Strain	None	Slight	Moderate	Severe
5.	Difficulty Focusing	None	Slight	Moderate	Severe
6.	Increased Salivation	None	Slight	Moderate	Severe
7.	Cold Sweating (from discomfort or nervousness)	None	Slight	Moderate	Severe
8.	Warm Sweating (from room temperature or physical exertion)	None	Slight	Moderate	Severe
9.	Nausea	None	Slight	Moderate	Severe
10.	Difficulty Concentrating	None	Slight	Moderate	Severe
11.	Fullness of the Head	None	Slight	Moderate	Severe
12.	Blurred Vision	None	Slight	Moderate	Severe
13.	Dizzy (Eyes Open)	None	Slight	Moderate	Severe
14.	Dizzy (Eyes Closed)	None	Slight	Moderate	Severe
15.	Vertigo *	None	Slight	Moderate	Severe
16.	Stomach Awareness **	None	Slight	Moderate	Severe
17.	Burping	None	Slight	Moderate	Severe
18.	Boredom	None	Slight	Moderate	Severe
19.	Drowsiness	None	Slight	Moderate	Severe
20.	Decreased Salivation	None	Slight	Moderate	Severe
21.	Mental Depression	None	Slight	Moderate	Severe
22.	Visual Flashbacks ***	None	Slight	Moderate	Severe
23.	Faintness	None	Slight	Moderate	Severe
24.	Aware of Breathing	None	Slight	Moderate	Severe
25.	Loss of Appetite	None	Slight	Moderate	Severe
26.	Increased Appetite	None	Slight	Moderate	Severe
27.	Desire to Move Bowels	None	Slight	Moderate	Severe
28.	Confusion	None	Slight	Moderate	Severe
29.	Vomiting	None	Slight	Moderate	Severe
30.	Claustrophobia ****	None	Slight	Moderate	Severe

---

* Vertigo is a loss of orientation with respect to vertical

upright.

** Stomach awareness is a feeling of discomfort just short of nausea.

*** Visual flashbacks are illusions of movement when you are not in the simulator.

**** Claustrophobia is a fear of confined spaces.

Other Symptoms (specify) ____

____

APPENDIX C

Procedure Guide for Interviewing Trainee

1. How do you feel? ______________________________

2. Did you experience any discomfort while in the simulator?

   ____

   ____

   ____

3. Anything else? ______________________________

   ____

   - O upset stomach ______________________________

     ____

   - O dizziness ______________________________

     ____

   - O eye strain ______________________________

     ____

   - O claustrophobia ______________________________

     ____

4. Was the discomfort you experienced bad enough to interfere with your training? __________

5. In what way? ______________________________

   ____

6. How would you describe the temperature in the simulator? ____

7. So, would you say that the temperature was:

   cold cool about right warm hot

8. Did you enjoy your session in the simulator? __________
9. What did you like the best? ______________________________

10. What did you like the least? ______________________________

APPENDIX D

Trainee Physical Status Questionnaire

1. Are you in your usual state of fitness: YES NO

   If not, what is the nature of your illness (flu, cold, etc).

2. Please indicate all medication you have used in the past 24 hours:

   (a) NONE

   (b) Sedatives or tranquilizers

   (c) Aspirin, Tylenol, other analgesics

   (d) Anti-histamines

   (e) Decongestants

   (f) other (specify):

3. How many hours sleep did you get last night? ___ (Hours)

   Was this amount sufficient? YES NO

APPENDIX E

Severity Ratings for Each Individual Symptom Across Sessions

Table E-1

Frequency Distributions for Pre TDT Session SSQ Items

	Session 1 (n=31)		Session 2 (n=21)		Middle (n=25)		Last (n=26)	
General Discomfort								
None	25	(80.6%)	19	(90.5%)	24	(96.0%)	24	(92.3%)
Slight	6	(19.4%)	2	(9.5%)	1	(4.0%)	2	(7.7%)
Moderate								
Severe								
mean score	.194		.095		.040		.077	
Fatigue								
None	17	(54.8%)	16	(76.2%)	16	(64.0%)	20	(76.9%)
Slight	11	(35.5%)	5	(23.8%)	8	(32.0%)	5	(19.2%)
Moderate	3	(9.7%)			1	(4.0%)	1	(3.8%)
Severe								
mean score	.548		.238		.400		.269	
Headache								
None	25	(80.6%)	19	(90.5%)	24	(96.0%)	24	(92.3%)
Slight	4	(12.9%)	1	(4.8%)	0		2	(7.7%)
Moderate	2	(6.5%)	1	(4.8%)	1	(4.0%)		
Severe								
mean score	.258		.143		.080		.077	

	Session 1 (n=31)		Session 2 (n=21)		Middle (n=25)		Last (n=26)	
Eye Strain								
None	29	(93.5%)	17	(81.0%)	23	(92.0%)	25	(96.2%)
Slight	2	(6.5%)	4	(19.0%)	2	(8.0%)	1	(3.8%)
Moderate								
Severe								
mean score	.065		.190		.080		.038	
Difficulty Focusing								
None	31	(100%)	18	(85.7%)	24	(96.0%)	26	(100%)
Slight			3	(14.3%)	1	(4.0%)		
Moderate								
Severe								
mean score	.000		.143		.040		.000	
Increased Salivation								
None	30	(96.8%)	20	(95.2%)	24	(96.0%)	26	(100%)
Slight	1	(3.2%)	1	(4.8%)	1	(4.0%)		
Moderate								
Severe								
mean score	.032		.048		.040		.000	

	Session 1 (n=31)		Session 2 (n=21)		Middle (n=25)		Last (n=26)	
Cold Sweating								
None	31	(100%)	20	(95.2%)	24	(96.0%)	25	(96.2%)
Slight			1	(4.8%)	0		1	(3.8%)
Moderate					1	(4.0%)		
Severe								
mean score	.000		.048		.080		.038	
Warm Sweating								
None	28	(90.3%)	20	(95.2%)	22	(91.7%)	26	(100%)
Slight	2	(6.5%)	1	(4.8%)	1	(4.2%)		
Moderate	1	(3.2%)			1	(4.2%)		
Severe								
mean score	.129		.048		.125 (n=24)		.000	
Nausea								
None	30	(96.8%)	18	(85.7%)	24	(96.0%)	22	(84.6%)
Slight	1	(3.2%)	3	(14.3%)	1	(4.0%)	3	(11.5%)
Moderate							1	(3.8%)
Severe								
mean score	.032		.143		.040		.192	

	Session 1 (n=31)	Session 2 (n=21)	Middle (n=25)	Last (n=26)
Difficulty Concentrat-ing				
None	24 (77.4%)	18 (85.7%)	23 (92.0%)	25 (96.2%)
Slight	7 (22.6%)	2 (9.5%)	2 (8.0%)	1 (3.8%)
Moderate		1 (4.8%)		
Severe				
mean score	.226	.190	.080	.038
Fullness of Head				
None	26 (86.7%)	19 (90.5%)	25 (100%)	25 (96.2%)
Slight	3 (10.0%)	2 (9.5%)		1 (3.8%)
Moderate	1 (3.3%)			
Severe				
mean score	.167 (n=30)	.095	.000	.038
Blurred Vision				
None	31 (100%)	20 (95.2%)	24 (96.0%)	26 (100%)
Slight		1 (4.8%)	1 (4.0%)	
Moderate				
Severe				
mean score	.000	.048	.040	.000

	Session 1 (n=31)	Session 2 (n=21)	Middle (n=25)	Last (n=26)
Dizzy (Eyes Open)				
None	31 (100%)	21 (100%)	25 (100%)	25 (96.2%)
Slight				1 (3.8%)
Moderate				
Severe				
mean score	.000	.000	.000	.038
Dizzy (Eyes Closed)				
None	30 (96.8%)	20 (95.2%)	25 (100%)	25 (96.2%)
Slight	1 (3.2%)	1 (4.8%)		1 (3.8%)
Moderate				
Severe				
mean score	.032	.048	.000	.038
Vertigo				
None	31 (100%)	20 (95.2%)	25 (100%)	26 (100%)
Slight		0		
Moderate		1 (4.8%)		
Severe				
mean score	.000	.095	.000	.000

	Session 1 (n=31)	Session 2 (n=21)	Middle (n=25)	Last (n=26)
Stomach Awareness				
None	28 (90.3%)	19 (90.5%)	24 (96.0%)	22 (84.6%)
Slight	3 (9.7%)	2 (9.5%)	1 (4.0%)	4 (15.4%)
Moderate				
Severe				
mean score	.097	.095	.040	.154
Burping				
None	29 (93.5%)	20 (95.2%)	25 (100%)	25 (96.2%)
Slight	2 (6.5%)	1 (4.8%)		1 (3.8%)
Moderate				
Severe				
mean score	.065	.048	.000	.038
Boredom				
None	30 (96.8%)	20 (95.2%)	24 (96.0%)	22 (84.6%)
Slight	1 (3.2%)	1 (4.8%)	0	4 (15.4%)
Moderate			0	
Severe			1 (4.0%)	
mean score	.032	.048	.120	.154

	Session 1 (n=31)		Session 2 (n=21)		Middle (n=25)		Last (n=26)	
Drowsiness								
None	15	(48.4%)	13	(61.9%)	18	(72.0%)	21	(80.8%)
Slight	12	(38.7%)	8	(38.1%)	5	(20.0%)	4	(15.4%)
Moderate	4	(12.9%)			1	(4.0%)	1	(3.8%)
Severe					1	(4.0%)		
mean score	.645		.381		.400		.231	
Decreased Salivation								
None	30	(96.8%)	21	(100%)	24	(96.0%)	26	(100%)
Slight	1	(3.2%)			0			
Moderate					0			
Severe					1	(4.0%)		
mean score	.032		.000		.120		.000	
Mental Depression								
None	30	(96.8%)	20	(95.2%)	24	(96.0%)	25	(96.2%)
Slight	1	(3.2%)	0		1	(4.0%)	1	(3.8%)
Moderate			1	(4.8%)				
Severe								
mean score	.032		.095		.040		.038	

	Session 1 (n=31)	Session 2 (n=21)	Middle (n=25)	Last (n=26)
Visual Flashbacks				
None	31 (100%)	21 (100%)	25 (100%)	26 (100%)
Slight				
Moderate				
Severe				
mean score	.000	.000	.000	.000
Faintness				
None	30 (96.8%)	20 (95.2%)	25 (100%)	26 (100%)
Slight	1 (3.2%)	1 (4.8%)		
Moderate				
Severe				
mean score	.032	.048	.000	.000
Aware of Breathing				
None	31 (100%)	20 (95.2%)	25 (100%)	26 (100%)
Slight		1 (4.8%)		
Moderate				
Severe				
mean score	.000	.048	.000	.000

	Session 1 (n=31)	Session 2 (n=21)	Middle (n=25)	Last (n=26)
Loss of Appetite				
None	28 (90.3%)	19 (90.5%)	25 (100%)	26 (100%)
Slight	3 (9.7%)	1 (4.8%)		
Moderate		1 (4.8%)		
Severe				
mean score	.097	.143	.000	.000
Increased Appetite				
None	23 (74.2%)	20 (95.2%)	24 (96.0%)	25 (96.2%)
Slight	8 (25.8%)	0	1 (4.0%)	1 (3.8%)
Moderate		1 (4.8%)		
Severe				
mean score	.258	.095	.040	.038
Desire to Move Bowels				
None	29 (93.5%)	21 (100%)	24 (96.0%)	26 (100%)
Slight	2 (6.5%)		1 (4.0%)	
Moderate				
Severe				
mean score	.065	.000	.040	.000

	Session 1 (n=31)	Session 2 (n=21)	Middle (n=25)	Last (n=26)
Confusion				
None	29 (93.5%)	20 (95.2%)	25 (100%)	26 (100%)
Slight	2 (6.5%)	1 (4.8%)		
Moderate				
Severe				
mean score	.065	.048	.000	.000
Vomiting				
None	31 (100%)	20 (95.2%)	25 (100%)	25 (96.2%)
Slight		1 (4.8%)		1 (3.8%)
Moderate				
Severe				
mean score	.000	.048	.000	.038
Claustro-phobia				
None	31 (100%)	20 (95.2%)	24 (96.0%)	26 (100%)
Slight		0	1 (4.0%)	
Moderate		1 (4.8%)		
Severe				
mean score	.000	.095	.040	.000

Table E-2

Frequency Distributions for Post TDT Session SSQ Items

	Session 1 (n=62)		Session 2 (n=50)		Middle (n=47)		Last (n=61)	
General Discomfort								
None	39	(65.0%)	33	(66.0%)	40	(85.1%)	52	(85.2%)
Slight	16	(26.7%)	13	(26.0%)	7	(14.9%)	6	(9.8%)
Moderate	4	(6.7%)	4	(8.0%)			3	(4.9%)
Severe	1	(1.7%)						
mean score	.450	(n=60)	.420		.149		.197	
Fatigue								
None	46	(76.7%)	38	(76.0%)	39	(83.0%)	49	(80.3%)
Slight	11	(18.3%)	11	(22.0%)	7	(14.9%)	9	(14.8%)
Moderate	3	(5.0%)	1	(2.0%)	1	(2.1%)	3	(4.9%)
Severe								
mean score	.283	(n=60)	.260		.191		.246	
Headache								
None	43	(70.5%)	42	(84.0%)	36	(76.6%)	52	(85.2%)
Slight	15	(24.6%)	6	(12.0%)	10	(21.3%)	8	(13.1%)
Moderate	2	(3.3%)	2	(4.0%)	1	(2.1%)	1	(1.6%)
Severe	1	(1.6%)						
mean score	.361	(n=61)	.200		.255		.164	

	Session 1 (n=62)	Session 2 (n=50)	Middle (n=47)	Last (n=61)
Eye Strain				
None	49 (81.7%)	38 (76.0%)	41 (87.2%)	48 (78.7%)
Slight	9 (15.0%)	9 (18.0%)	6 (12.8%)	12 (19.7%)
Moderate	2 (3.3%)	3 (6.0%)		1 (1.6%)
Severe				
mean score	.217 (n=60)	.300	.128	.230
Difficulty Focusing				
None	55 (91.7%)	42 (85.7%)	42 (89.4%)	60 (98.4%)
Slight	3 (5.0%)	5 (10.2%)	5 (10.6%)	0
Moderate	2 (3.3%)	2 (4.1%)		1 (1.6%)
Severe				
mean score	.117 (n=60)	.184 (n=49)	.106	.033
Increased Salivation				
None	57 (95.0%)	44 (93.6%)	47 (100%)	60 (98.4%)
Slight	3 (5.0%)	2 (4.3%)		1 (1.6%)
Moderate		1 (2.1%)		
Severe				
mean score	.050 (n=60)	.085 (n=47)	.000	.016

	Session 1 (n=62)		Session 2 (n=50)		Middle (n=47)		Last (n=61)	
Cold Sweating								
None	46	(79.3%)	42	(84.0%)	43	(91.5%)	61	(100%)
Slight	5	(8.6%)	3	(6.0%)	4	(8.5%)		
Moderate	7	(12.1%)	4	(8.0%)				
Severe			1	(2.0%)				
mean score	.328	(n=58)	.280		.085		.000	
Warm Sweating								
None	42	(68.9%)	36	(73.5%)	41	(89.1%)	55	(90.2%)
Slight	14	(23.0%)	7	(14.3%)	5	(10.9%)	5	(8.2%)
Moderate	3	(4.9%)	4	(8.2%)			1	(1.6%)
Severe	2	(3.3%)	2	(4.1%)				
mean score	.426	(n=61)	.429	(n=49)	.109	(n=46)	.115	
Nausea								
None	40	(64.5%)	35	(71.4%)	42	(89.4%)	54	(90.0%)
Slight	12	(19.4%)	8	(16.3%)	5	(10.6%)	6	(10.0%)
Moderate	8	(12.9%)	6	(12.2%)				
Severe	2	(3.2%)						
mean score	.548		.408	(n=49)	.106		.100	

	Session 1 (n=62)		Session 2 (n=50)		Middle (n=47)		Last (n=61)	
Difficulty Concentrat-ing								
None	52	(86.7%)	42	(85.7%)	46	(97.9%)	58	(95.1%)
Slight	5	(8.3%)	6	(12.2%)	1	(2.1%)	3	(4.9%)
Moderate	3	(5.0%)	1	(2.0%)				
Severe								
mean score	.183	(n=60)	.163	(n=49)	.021		.049	
Fullness of Head								
None	49	(81.7%)	43	(86.0%)	45	(95.7%)	57	(93.4%)
Slight	9	(15.0%)	6	(12.0%)	2	(4.3%)	4	(6.6%)
Moderate	1	(1.7%)	1	(2.0%)				
Severe	1	(1.7%)						
mean score	.233	(n=60)	.160		.043		.066	
Blurred Vision								
None	54	(90.0%)	44	(89.8%)	46	(97.9%)	59	(96.7%)
Slight	5	(8.3%)	4	(8.2%)	1	(2.1%)	2	(3.3%)
Moderate	1	(1.7%)	1	(2.0%)				
Severe								
mean score	.117	(n=60)	.122	(n=49)	.021		.033	

	Session 1 (n=62)		Session 2 (n=50)		Middle (n=47)		Last (n=61)	
Dizzy (Eyes Open)								
None	47	(77.0%)	40	(80.0%)	42	(91.3%)	60	(98.4%)
Slight	11	(18.0%)	8	(16.0%)	4	(8.7%)	1	(1.6%)
Moderate	3	(4.9%)	2	(4.0%)				
Severe								
mean score	.279	(n=61)	.240		.087	(n=46)	.016	
Dizzy (Eyes Closed)								
None	50	(84.7%)	42	(87.5%)	43	(91.5%)	59	(96.7%)
Slight	7	(11.9%)	5	(10.4%)	4	(8.5%)	1	(1.6%)
Moderate	2	(3.4%)	1	(2.1%)			1	(1.6%)
Severe								
mean score	.186	(n=59)	.146	(n=48)	.085		.049	
Vertigo								
None	55	(90.2%)	46	(93.9%)	47	(100%)	60	(98.4%)
Slight	5	(8.2%)	2	(4.1%)			1	(1.6%)
Moderate	1	(1.6%)	1	(2.0%)				
Severe								
mean score	.115	(n=61)	.082	(n=49)	.000		.016	

	Session 1 (n=62)		Session 2 (n=50)		Middle (n=47)		Last (n=61)	
Stomach Awareness								
None	40	(64.5%)	40	(80.0%)	44	(93.6%)	57	(93.4%)
Slight	15	(24.2%)	5	(10.0%)	3	(6.4%)	4	(6.6%)
Moderate	6	(9.7%)	5	(10.0%)				
Severe	1	(1.6%)						
mean score	.484		.300		.064		.066	
Burping								
None	55	(90.2%)	45	(91.8%)	47	(100%)	59	(96.7%)
Slight	4	(6.6%)	2	(4.1%)			2	(3.3%)
Moderate	2	(3.3%)	2	(4.1%)				
Severe								
mean score	.131	(n=61)	.122	(n=49)	.000		.033	
Boredom								
None	58	(96.7%)	45	(91.8%)	43	(91.5%)	56	(91.8%)
Slight	2	(3.3%)	2	(4.1%)	2	(4.3%)	3	(4.9%)
Moderate			2	(4.1%)	1	(2.1%)	1	(1.6%)
Severe					1	(2.1%)	1	(1.6%)
mean score	.033	(n=60)	.122	(n=49)	.149		.131	

	Session 1 (n=62)		Session 2 (n=50)		Middle (n=47)		Last (n=61)	
Drowsiness								
None	44	(72.1%)	36	(75.0%)	40	(85.1%)	51	(83.6%)
Slight	16	(26.2%)	11	(22.9%)	3	(6.4%)	7	(11.5%)
Moderate	1	(1.6%)	1	(2.1%)	3	(6.4%)	3	(4.9%)
Severe					1	(2.1%)		
mean score	.295	(n=61)	.271	(n=48)	.255		.213	
Decreased Salivation								
None	58	(96.7%)	48	(98.0%)	46	(97.9%)	59	(96.7%)
Slight	2	(3.3%)	1	(2.0%)	1	(2.1%)	2	(93.3%)
Moderate								
Severe								
mean score	.033	(n=60)	.020	(n=49)	.021		.033	
Mental Depression								
None	56	(93.3%)	45	(91.8%)	44	(93.6%)	60	(98.4%)
Slight	3	(5.0%)	2	(4.1%)	1	(2.1%)	0	
Moderate	1	(1.7%)	2	(4.1%)	2	(4.3%)	1	(1.6%)
Severe								
mean score	.083	(n=60)	.122	(n=49)	.106		.033	

	Session 1 (n=62)		Session 2 (n=50)		Middle (n=47)		Last (n=61)	
Visual Flashbacks								
None	59	(98.3%)	46	(93.9%)	45	(95.7%)	60	(98.4%)
Slight	1	(1.7%)	2	(4.1%)	2	(4.3%)	0	
Moderate			1	(2.0%)			1	(1.6%)
Severe								
mean score	.017	(n=60)	.082	(n=49)	.043		.033	
Faintness								
None	56	(93.3%)	46	(93.9%)	47	(100%)	60	(98.4%)
Slight	4	(6.7%)	2	(4.1%)			1	(1.6%)
Moderate			1	(2.0%)				
Severe								
mean score	.067	(n=60)	.082	(n=49)	.000		.016	
Aware of Breathing								
None	58	(98.3%)	48	(98.0%)	46	(100%)	61	(100%)
Slight	0		0					
Moderate	1	(1.7%)	1	(2.0%)				
Severe								
mean score	.034	(n=59)	.041	(n=49)	.000	(n=46)	.000	

	Session 1 (n=62)		Session 2 (n=50)		Middle (n=47)		Last (n=61)	
Loss of Appetite								
None	52	(86.7%)	44	(89.8%)	45	(95.7%)	61	(100%)
Slight	5	(8.3%)	3	(6.1%)	1	(2.1%)		
Moderate	1	(1.7%)	1	(2.0%)	1	(2.1%)		
Severe	2	(3.3%)	1	(2.0%)				
mean score	.217	(n=60)	.163	(n=49)	.064		.000	
Increased Appetite								
None	47	(78.3%)	43	(87.8%)	45	(95.7%)	55	(90.2%)
Slight	11	(18.3%)	5	(10.2%)	1	(2.1%)	4	(6.6%)
Moderate	2	(3.3%)	0		1	(2.1%)	1	(1.6%)
Severe			1	(2.0%)			1	(1.6%)
mean score	.250	(n=60)	.163	(n=49)	.064		.148	
Desire to Move Bowels								
None	57	(95.0%)	43	(87.8%)	44	(93.6%)	60	(98.4%)
Slight	1	(1.7%)	5	(10.2%)	3	(6.4%)	1	(1.6%)
Moderate	2	(3.3%)	0					
Severe			1	(2.0%)				
mean score	.083	(n=60)	.163	(n=49)	.064		.016	

	Session 1 (n=62)		Session 2 (n=50)		Middle (n=47)		Last (n=61)	
Confusion								
None	55	(91.7%)	45	(91.8%)	47	(100%)	61	(100%)
Slight	4	(6.7%)	2	(4.1%)				
Moderate	1	(1.7%)	2	(4.1%)				
Severe								
mean score	.100	(n=60)	.122	(n=49)	.000		.000	
Vomiting								
None	56	(93.3%)	47	(95.9%)	47	(100%)	61	(100%)
Slight	2	(3.3%)	2	(4.1%)				
Moderate	1	(1.7%)						
Severe	1	(1.7%)						
mean score	.117	(n=60)	.041	(n=49)	.000		.000	
Claustro-phobia								
None	57	(95.0%)	44	(91.7%)	46	(97.9%)	60	(98.4%)
Slight	3	(5.0%)	1	(2.1%)	1	(2.1%)	1	(1.6%)
Moderate			3	(6.3%)				
Severe								
mean score	.050	(n=60)	.146	(n=48)	.021		.016	

Appendix F

Instructor/Operator Interviews

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Background

Training is typically conducted at the M1 Tank Driver Trainer (TDT) facility six days a week in three sessions: 0800-1150, 1300-1650, and 1800-2200. The fifty-four Instructor/Operators (I/O's) who conduct the simulator training are divided into three groups: morning, afternoon, and military. The 19 morning I/O's work from 0600-1400 to cover the first training session and part of the second, whereas the 18 afternoon I/O's work from 1400-2200 to cover the remainder of the second training session and the third. The 17 military I/O's are active-duty Army personnel who work the weekend training sessions and fill-in on the morning and afternoon shifts during the week. Civilian I/O's work either Monday-Friday or Tuesday-Saturday and stay on either the morning or afternoon shift. Military I/O's are assigned to either the morning or afternoon shift but can work either. All civilians except for one are assigned to a particular simulator. Military I/O's are not assigned to simulators.

Procedure

All 19 morning I/O's and 2 of the military I/O's were interviewed. Each interview was conducted according to the following procedure. The interviewer and the I/O went into a private area of the training site. A standard introduction was verbally given by the interviewer in which the I/O was informed about the purpose of the interview and that all information would remain confidential. In addition, permission to record the interview was requested.

The interview consisted of a standard set of questions asked by the interviewer. The same interviewer conducted all of the interviews. Notes were taken during the interview and, later, a near-transcript of the interview was made from the tape by the interviewer. The interview was intended to be no longer than 30 minutes but most lasted only about 15 minutes and none were longer than 30 minutes.

After gathering some biographical data on the I/O, the I/O was given an opportunity to say whatever he or she wanted to about sickness before specific questions were asked. Throughout the interview, the I/O was welcome to make comments in addition to answering the specific questions. Thus, two kinds of data were gathered during the interview: answers to specific questions and free-response/additional comments data. The exact interview questions followed by a summary of the answers to the specific questions are presented in the following "Questionnaire Results" section. The last section, "Free-Response Comments", provides a summary of some of the free-response/additional comments.

Questionnaire Results

B1. How long have you been an I/O?. One of the I/O's indicated that I/O's are brought in in classes. Thus, most of the I/O's (81.0%) have been at the TDT for 8-12 months (relative to August 1994), with the majority of these (42.9% overall) having been there for 10 months. The remaining 19.0% have been there for various amounts of time longer.

B2. Approximately how many soldiers do you think you've trained?. It was hard for I/O's to estimate how many soldiers they think they've trained. A better estimate is how many they typically train each day. This number varied from 1 to 6. Typically, two trainees are assigned to each simulator during a training session so, since each shift includes two sessions, the majority (42.9%) indicated that they train 4 soldiers each day. This number could vary, however, if systems are down for one reason or another and more than two trainees are put on a simulator. Also, towards the end of a platoon's TDT training, some trainees might be given extra time in the simulator to make up training hours.

B3. Do you have any M1 tank driving experience?. The majority of the I/O's - 17 (81.0%) - indicated that they do have at least some experience in the M1. The remainder indicated that they do not. All I/O's receive a day's training in the M1 as part of I/O training, so all should have indicated that they have some experience.

B3a. How much experience?. Of the 17 I/O's indicating that they had M1 tank driving experience, 5 (29.4%) indicated that their experience consisted only of the familiarization course as part of their I/O training. For the remainder, experience varied from periodic experience to that gained when the individual was a mechanic or tank commander.

B3b. How well do you think the TDT corresponds to M1?. Of the 17 I/O's indicating that they had M1 tank driving experience, all thought that the TDT corresponded well to the M1.

B3c. What aspects of the TDT do not correspond to the M1?. When asked what aspects of the TDT do not correspond to the M1, the 17 I/O's indicating that they had M1 tank driving experience gave various answers and several gave more than one response. The most common response (4/17) was that the TDT has no feeling of mass. Another common response (3/17) was that the TDT is harder to control/more sensitive than the M1. Other responses given by either one or two of the 17 I/O's were that: (a) there are differences between the M1 and TDT in stopping/braking, steering, perspective from the driver's seat, and throttle response; (b) in the TDT, there is too soft of a ride, an exaggerated feel/movement (especially during flat, slow, motor

pool driving), and a lag between stick input and simulator output; (c) there is a lack of sickness in the M1; (d) there is less clutter in the TDT driver's compartment; (e) a driver can do things in the TDT which can not be done in the M1 (e.g., driving sideways on an 80° slope, jumping over cliffs and sailing, and some hard collisions); (f) the M1 doesn't skid and slide like the TDT does; and (g) there is no danger in the TDT.

Q1. Do you feel that simulator sickness is a problem in the M1TDT? / Q1a. How much of a problem do you feel it is?. The majority of the I/O's (61.9%) felt that simulator sickness is not a problem in the M1TDT. One I/O commented that they overbrief about sickness and underbrief about the job to be done while driving. Another I/O stated that the few that do get sick seem to overshadow the whole thing.

The remainder felt that it is a problem to some degree. One I/O noted that sickness was a bigger problem when the trainers were new but is no longer a problem now that the I/O's are familiar with both the trainers and sickness. Another I/O noted that it goes in classes: some classes get sick more than others. Finally, one I/O suggested that most of sickness can be avoided by just getting the trainee relaxed. This idea of the trainees being nervous and needing to relax was a recurrent theme throughout these interviews.

Q2. What do you estimate the incidence of sickness is?. Answers varied greatly as to the estimated incidence of sickness. Most I/O's (47.6%) felt that the incidence is very slight overall, representing 1-2 trainees/platoon or 1-2 trainees/week. The rest of the I/O's estimated the incidence to be anywhere from a maximum of 1% to 25%. One I/O stated that incidence varies with platoon - in some platoons, only 1 or 2 trainees get sick but, in other platoons, as many as half get sick. In fact, several I/O's recalled a whole platoon that got sick.

Several I/O's made reference to the sickness rate changing over the course of training. It is highest with first-time drivers and decreases over the course of training. In addition, a few I/O's noted that the sickness rate depends somewhat on how one defines sickness. Dizziness or queasiness appear to be more common than vomiting. Finally, a few I/O's suggested that some trainees may use the excuse of "sickness" to get out of training and that this may have been a case with the whole platoon, mentioned above, which got sick.

Q3. Have you ever received formal training in simulator sickness recognition?. Most I/O's (57.1%) responded that they had not received formal training in simulator sickness recognition. The rest responded that they had and 33.3% (of all I/O's) indicated that they had received training during the I/O course. According to the *M1 Tank Driver Trainer Student Guide* [General Electric Company. (3 February 1992). M1 Tank Driver Trainer Student Guide (Volume 1) (document number 81B-M003-TDT-I/O-1).

Daytona Beach, Florida: Author.], which the I/Os allegedly receive during their training, simulator sickness is discussed. Thus, all I/O's should have indicated that they had received formal training in sickness recognition.

Q4. How do you recognize simulator sickness? In other words, what do you consider to be the symptoms of simulator sickness?. The I/O's mentioned many different symptoms which they use to identify sickness in a trainee. All but one indicated a combination of symptoms and no two I/O's indicated the same combination. Some I/O's (19.1%) rely primarily on the trainee to tell them how he feels and at least one I/O stated that, most of the time, the student will let the I/O know that he is not feeling well. Another I/O, however, claimed that you cannot rely on trainees to tell you if they're feeling sick.

For those I/O's who look for symptoms of simulator sickness, the most common symptom identified (57.1%) was that the trainee complains of being sweaty. Related symptoms indicated by anywhere from 1 to 9 of the I/O's were as follows: (a) the trainee complains of nausea, dizziness/lightheadedness, headache, blurred vision, or feeling hot/warm; (b) changes in the trainee's voice/speech, breathing, or driving/controls; (c) the trainee burps or gets quiet/is slow to answer; (d) after exiting the TDT, the trainee walks around looking confused, is pale, or shows signs of sickness in his eyes; and/or (e) the I/O notices that the trainee's record indicates a past incidence of sickness.

Several I/O's said that very few trainees actually vomit and that most do not get past the nausea/headache stage because the I/O's let them out before the get any worse.

Q5. Which scenarios have you observed to be the most sickness-inducing?. One I/O answered that sickness is not a function of the scenario itself, even though this I/O noted that the early scenarios may be sickness-inducing and trainees may be claustrophobic at first. The I/O explained that the first time a trainee comes to the TDT is normally when he gets sick - normally by the middle of the first scenario or the end of the second. The I/O added that if a trainee can make it through the first and second scenarios, he probably won't get sick.

Except for this I/O, all others identified at least two sickness-inducing scenarios but only four I/O's indicated the same combination: two I/O's indicated both scenarios 10110 and 10111 and two I/O's indicated both scenarios 10210 and 10110.

The total frequencies for all identified scenarios (including the combinations mentioned above), as well as a brief description of the scenarios, appear in Table F-1 below.

Table F-1

Frequency of responses for Question 5

frequency	scenario	description
17	10210	motor pool/ground guide; open hatch; day
17	10110	slalom course; open hatch; day
9	10111	slalom course; closed hatch; day
7	13970	steep hills; open hatch; day
7	10211	motor pool/ground guide; open hatch; night
4	20110	free play; open/closed hatch; day
1	10510	loading the tank on a HET; open hatch; day
1	10310	loading the tank on a rail car; open hatch; day

With the POI that was in use while the I/O's were being interviewed, the order that a trainee went through the first several scenarios was as follows: 20110 & 10210 in the first hour; 13970 & 10110 in the second hour; 11610 (village driving; open hatch, night) & 10111 in the third hour; and 11251w (urban driving, winter, closed hatch, day) & 10211 in the fourth hour.

As can be seen in Table F-1, the two most frequently noted scenarios - each noted by 81.0% of the I/O's - were 10210 and 10110. These are the second and fourth scenarios that a trainee drives, respectively. Several I/O's indicated that once a trainee gets past these scenarios, he is usually okay.

In 10210, a ground guide directs the tank driver around a motor pool and through various maneuvers such as parking. Several I/O's offered suggestions as to the problematic elements in this scenario such as that it involves intense driving, the trainee has to pay strict attention to the ground guide, and that the trainee does a lot of pivot steering. Two I/O's indicated that this scenario is problematic because it occurs right after the free run. One of these I/O's has had good results with alternating the two scenarios (20110, 10210) between the two trainees.

Scenario 10110 starts with a slalom course in which the trainee must drive the tank around and through a series of pylons. This portion of the scenario is followed by driving on a winding course. Three I/O's indicated that it is the sharp, hard right and left turns around the pylons which are problematic in this scenario. Another I/O indicated that it is the combination

of winding around the pylons and then going on the road which is the problem.

The third most sickness-inducing scenario - identified by 42.9% of the I/O's - is 10111. This is the same slalom course which the trainees drive in 10110 except with closed hatch. One I/O commented that the trainee does not need both of these scenarios - specifically, not the closed hatch one.

The next two scenarios most often identified - each by 33.3% of the I/O's - were 10211 and 13970. In scenario 13970, the trainee drives the tank over steep mountain roads. A few I/O's indicated the problematic elements of this scenario: the hard right and left turns; a lot of points where the trainee comes up over an incline and can see out of the driver's compartment but can't see the road; and the fact that the trainee isn't used to vehicle control by the time he drives this scenario. Another I/O indicated that this scenario is only bad if done right after 10210; if the trainee gets a break between the two, he's usually okay.

Only 4 I/O's identified a trainee's first scenario - 20110 - as sickness-inducing and each had a comment about it. One claimed that this scenario will weed out those trainees who naturally get sick from the motion. Another indicated that trainees only occasionally get sick on this scenario and it depends upon how much the I/O lets him run cross country before stopping him. Because it made a lot of trainees get sick, the third I/O has stopped the practice of running them through the scenario and, at the end, showing them what a hard collision is like. Finally, the fourth I/O indicated that even trainees who never get sick again sometimes get sick on the free run and that sickness starts with the pivot steer.

Two other scenarios were identified as sickness-inducing by one I/O: 10510 and 10310 (Our examination of I/O records of several companies that had previously trained with the TDT did not reveal any incidents of simulator sickness associated with these two scenarios). According to this I/O, the problem is the same in both of them: because of where the tank driver sits, it appears to the student that he will drive off of the HET (in 10510) or rail car (in 10310); the I/O can often hear the trainee gasp from apprehension. To alleviate this problem, the I/O recommended to the company commander that the Drill Sergeant explain to the trainee how he will view things from the driver's compartment.

Several I/O's commented on the two motor pool scenarios: 10210 and 10211. One I/O felt that the ground guide should be at the beginning and end of every scenario, rather than a full scenario. In the case one scenario devoted to the ground guide, however, the I/O felt that the scenario should occur at least halfway into the POI. This would give the trainee a chance to become somewhat proficient at using the throttle and brake and, thus, eliminate a lot of bouncing and rolling which, this I/O felt, contributes to sickness. This I/O noted that, in the original POI, the ground guide scenarios were at the end and that

sickness was not as bad then. Another I/O noted that, on the previous POI, the first 6 or 7 scenarios were motor pools and that trainees were sick constantly. Finally, some I/O's felt that the two motor pool scenarios should be taken out of the program entirely. They commented that the ground guide often gives confusing, unnecessary, or unrealistic signals.

Q6. How quickly does sickness usually come on either from simulator entry or once a scenario begins?. Since this question was free-response with no suggested metric, the answers were somewhat hard to categorize. The majority of the I/O's (61.9%) emphasized that it varies with the individual and the scenario. Most of the remaining 38.1% of the I/O's gave some type of time estimate, ranging from 5 to 15 minutes. Three I/O's didn't give specific time estimates. One said that it comes on spur of the moment and the other two said that sickness comes on either towards the end of the first scenario or halfway into the second. One of these I/O's noted, however, that the trainee may just not mention it until he's into his second or third scenario.

Q6a. Do trainees tend to get sick in pairs? - In other words, if the first trainee gets sick, is the second one more likely to?. The majority of the I/O's (76.2%) answered that this was not the case. Several I/O's made comments such as that (a) if the first trainee gets sick, the second tries to one-up him and not get sick; and (b) unless there is a mess and smell in the cab, the I/O can usually talk the second one out of being apprehensive. Conversely, one I/O suggested that once a sick trainee sees the other trainee go in, he may want to go back in to prove he doesn't get sick anymore.

A small percentage of I/O's (19.0%), answered that trainees do tend to get sick in pairs. Some of these I/O's made comments to the effect that one trainee getting sick makes the other more nervous about it. One of these I/O's summed it up by saying that it's more or less a psychological effect: "the more they talk, the more it will spread like a disease".

Finally, one I/O said that trainees did tend to get sick in pairs in the beginning (when the TDT first started), but it hasn't occurred lately.

Q7. What do you do when you realize a trainee is sick?. All but one I/O discussed several things that they do when they realize a trainee is sick, but none described the exact same procedure. The comments were broken down into several categories which formed, roughly, two groups: actions performed while the trainee was still in the simulator or when he was put back in the simulator (if he was put back in) and actions performed once the trainee got out of the simulator.

All I/O's indicated that, at some point, they would stop the TDT and bring the trainee down. Some indicated that they would do that at the first sign of sickness but others indicated that they would try several things before bringing a trainee down right

away such as: (a) talking to the trainee and try to "talk him out of sickness" or get his mind off of sickness; (b) taking the motion out; (c) trying to get the trainee to breathe slowly/deeply and relax; (d) advising the trainee to look around at screens; (e) bringing the trainee's attention to the cool air in the cab; and/or (f) having the trainee put the gas particulate filter up through his shirt to blow on his face. Some I/O's would try to get trainee to finish the scenario; others might ask the trainee how sick he is or just try to make sure to get him out before he vomits; others added that they would make sure trainee exits the TDT okay or would escort the trainee down.

The I/O's identified several things they do once a sick trainee comes down. Most common (80.9%) was to let the trainee cool off or get fresh air. Many indicated that they let the trainee get water but some warned that he should only have a sip or should just use the water to moisten his mouth and that he should not have cold water or sodas. Two I/O's indicated that they advise the trainee to lay his head down or put his head between his legs or sit down and lower head and one advised this over watching the I/O screens. Other actions were to: (a) let the trainee walk around, "get his equilibrium back", or go to latrine; (b) let trainee wash his face or put cold water on his face and back of his neck; or (c) tell trainee that it's normal to get sick and relay to him how the I/O got sick the first time in the trainer.

Opinions were mixed as to whether or not a sick trainee can or should go back in the trainer. Some felt that if a trainee gets out before he gets sick, he can usually "get his bearings together" and go back in again. They indicated that, after about a 20 minute break, they would try the trainee on the next scenario or would try him again without motion. Many I/O's, however, felt that the trainee should not be put back in the TDT and that if he gets really sick, he's usually through for the day and will not want to get back in. One I/O encourages trainees not to drive any more if they are really sick because they will likely get sick again and the sicker they get, the more afraid they will be the next time. Some I/O's noted that if a trainee gets sick and then sits down at the console and observes the monitors, he'll get even sicker.

Q7a. <u>What is the documentation procedure?</u>. Most of the I/O's (42.9%) indicated that they make a note on the observation and cover sheets in the trainee's folder, log it on the jacket and I/O sheet, and/or note "motion sickness" on record. Several of these I/O's described the data they record: (a) the scenario, how far into it the trainee was/in what portion the trainee got sick, and whether or not he completed the scenario; (b) how long the trainee was in the simulator; (c) whether or not the trainee went back in; and (d) whether the trainee actually got sick (vomited) or was just feeling bad. Not all of the 42.9% reported recording all of this information, however. A smaller percentage (23.8%) of I/O's indicated that, in addition to some or all of

the above actions, they also leave a note with and/or tell the supervisor or Drill Sergeant.

It was clear from the widely varying answers that there is no definitive I/O documentation procedure for sickness cases.

Q7b. If he cannot continue, what do you do?. If trainee was too sick to continue driving, the majority of I/O's (47.6%) indicated that they would send him back to the Drill Sergeant. Some of these I/O's added they would report to the office/supervisor that the trainee got sick and could not continue. The next most common response (33.3%) was to put the trainee in the classroom/break room. Several I/O's noted that the trainee could observe training from the I/O station if he wanted to. One I/O indicated that an attempt would be made to continue training without running the TDT or without using the motion platform.

Q7c. Do you send him to the infirmary?. All of the I/O's indicated that they do not send trainees to the infirmary. Several indicated that they are not authorized to do so and that it is the job of the Drill Sergeant, but they can recommend to the Drill Sergeant that a trainee be sent. One I/O indicated that a trainee is sent to the infirmary to get motion sickness pills if he gets sick two or three times. However, as another I/O explained, dramamine is available in the PX and this I/O felt that most trainees know about it before they ever come to the TDT. One I/O does not feel trainees should go to the infirmary anymore because the infirmary is making it "such a hassle". According to the reports this I/O has received from some trainees, the infirmary has told trainees that if they didn't throw up, then they're not sick enough to take anything.

Q8. How long does sickness usually last once a soldier leaves the trainer?. From the first couple of interviews, it was clear that the I/O's would not be able to adequately answer this question since they do not see the trainees once they leave the TDT site. Thus, I/O's were instead asked how long they usually wait before trying to put a trainee back into the trainer after he's gotten sick.

Most of the I/O's (42.9%) responded that it's up to/depends on the student but that he would get a break of anywhere from 5 minutes to less than an hour. Several I/O's indicated that they just wait however long it takes to run the second trainee (approximately 15 to 30 minutes). Three of I/O's noted that if the trainee vomits, he wouldn't be put back in that day.

Q9. Do you think it would be helpful if you had a short, standardized form to use for documenting cases of simulator sickness?. Only two I/O's (9.5%) completely agreed that such a form would be helpful. Many more (33.3%) felt that such a form would not be helpful and several of them explained that they couldn't see how it would be better than what they do now and

that it would be inconvenient. One I/O was opposed to a form on the grounds that it would be asking I/O's to make a medical decision - something for which they are not trained. Most (38.1%) expressed concern that such a form would be "just another piece of paper" for the trainee's file (which, according to one I/O, only the I/O's read) and they questioned what such a form would be used for since the I/O's don't need to keep track of that kind of information.

One I/O suggested that such a form could be given to the trainee to take to the dispensary to eliminate waiting to see a medic and a couple of I/O's agreed with this suggestion, especially since they expressed concern that the infirmary has been "blowing trainees off" lately.

Q10. Through this research, we hope to develop a documentation form. What kinds of items do you think would be important to include on this form (i.e., what kinds of questions should be asked)?. The I/O's suggested many items which may be important to note for cases in which the trainee got sick. The most frequently suggested item (47.6%) was the scenario number or type of scenario the trainee was driving. Another frequent suggestion was the point in or time into the scenario or what the trainee was doing in scenario at time of sickness. One of the I/O's who recommended recording this explained that if someone is proficient with the exercise numbers and knows what they mean, then they know almost exactly where the trainee was and what he was doing when he got sick. According to this I/O, the important thing is what the trainee was doing at the time sickness occurred.

Other information which one or more I/O's thought may be important is as follows: (a) length of time the trainee was in the TDT before sickness occurred; (b) how the trainee felt/what specific symptoms he exhibited, and the severity of those symptoms: nausea/upset stomach, clamminess/sweating, vomiting, feeling hot, dizziness/disorientation, pallor, burping, headache, weakness, claustrophobia, or nervousness; (c) information on the general health/current fitness of the trainee before getting in TDT (e.g., if he was suffering from a cold, flu, respiratory ailments, etc.) and what, if any, medication he was taking; (d) recovery time and/or whether or not the trainee could drive again; (e) time between eating and training at the TDT and what was eaten; (f) if it was the trainee's first time getting sick; (g) if the trainee had a "wild night" the night before; (h) the time of day (e.g., before or after lunch); (i) activities before training at the TDT (e.g., strenuous PT, gas chamber, obstacle course, diagnostic PT test, running, etc.); (j) environmental conditions (e.g., air conditioner not working at TDT); (k) I/O observations from when trainee first arrives; and (l) a place for the trainee to say, in his own words, how he feels with a scale for rating specific symptoms (e.g., hot, queasy)

Free-Response Comments

This section contains a summary of comments that were made by the Instructor/Operators during the course of their interviews. Most of these comments were made during the "Free Response" portion of the interview or in response to the last question "Is there anything else you'd like to add?" The rest of the comments were extra information provided during the course of answering specific interview questions.

General. Overall, the I/O's had very positive things to say about the TDT. One summarized it by saying that if the student can master the trainer and do a reasonably good job with it, then he will be an excellent driver out on the actual vehicle.

Several I/O's noted that sickness depends a great deal upon the individual: how they feel that particular day, what week of training they're in, their physical health, what scenario the I/O's are in, and how the I/O approaches it with the student. Furthermore, some trainees are just more susceptible to sickness than others. One I/O suggested that the trainees who wear glasses are the most susceptible to sickness and another added that fatigue increases the risk of sickness.

Many of the I/O's indicated that they experienced sickness or still experience sickness in the TDT.

Nervousness and the psychological component of sickness. Virtually every I/O mentioned in some way that the trainees are told stories about sickness before they ever go for training at TDT - in effect, the trainees are told that they will get sick. Most I/O's implicated the Drill Sergeants, but some felt the I/O was also to blame. Most I/O's felt that the trainees are scared and nervous by the time they get to the TDT and that this plays a big role in sickness. They emphasized a psychological component of simulator sickness. Many commented that not emphasizing sickness too much and making sure the trainees are relaxed during training improves training and eliminates or lessens sickness.

Trying to avoid sickness. Before entering the TDT for training, the I/O gives the trainee a safety briefing. This briefing mostly concerns such things as fire, blackout, and hydraulic failure, but some I/O's mentioned that, if the trainee appears nervous, they will use that time to try and calm the trainee down. Some I/O's try to relate it to a carnival ride, video game, or something the trainee enjoys. Other I/O's warned against talking too much about sickness as that may only exacerbate the problem. A few I/O's emphasized that the I/O's have a lot of control and can make a difference in whether or not a soldier gets sick or not. Some noted that it is important to let the trainee know that the I/O will pull him out if he starts feeling sick - knowing that he is able to get out is important. Finally, one I/O pointed out that each scenario has a teaching point and that concentrating on it helps prevent sickness.

Several I/O's emphasized the importance of looking around while in the TDT. They commented that trainees get sick because they fixate on one place such as staring at the white line in the slalom course or at the ground guide in the motor pool. Scenarios 10110, 10111, 10210, and 10211 were identified by one I/O as ones which force drivers to look at and stay with the center screen - a contributing factor to sickness. These I/O's warn the trainees not to stare at the middle screen but, rather, to look at all three screens. Some I/O's also warn trainees not to look at the screens when they are blacked out because of the glare.

Some I/O's mentioned that the person in charge of bringing trainees to the TDT should also monitor what they eat. These I/O's felt that heavy and greasy foods, especially, are problematic and that there is more sickness when trainees come to the TDT right after lunch. One I/O noted that when they come later in the day, there is, generally, less sickness once they've eaten. This I/O felt that when the first trainee is run for the first hour or so, the second trainee stands a better chance of not getting sick because he's had some time for his meal to settle.

Factors which might be involved in sickness. Several I/O's commented that how the trainee controls the TDT plays a big role in whether or not he gets sick. For example, poor throttle and brake control may create a lot of jumping and jerking which may lead to sickness. One I/O felt that once a trainee gets settled down and starts driving smoothly, sickness goes away. This I/O felt that if I/O's stressed smooth driving with the trainees, it would eliminate a lot of sickness.

Several I/O's recommended that more cool air be added in the cab because it gets hot in there. One suggested a fan be added to blow air over the driver. Some indicated that they use the gas particulate filter in this capacity. Along these same lines, a couple of I/O's suggested that a wind reference be added since there would be one in the real vehicle.

Some I/O's pointed to the screens as the source of problems. A suggested alternative to the parabolic mirrors was a solid oval/half moon screen to eliminate blank spots where the mirrors join. Others noted that the reflections from the lights in the cab on the blank screens can be unsettling if an individual stares at them.

A couple of I/O's felt that the motion component is a factor in sickness - especially if there is a lag between the visuals and the motion of the platform.

One I/O noted that the seat in the TDT can sometimes cause discomfort to the trainee. Because tight pants may exacerbate the problem, this particular I/O may have trainees loosen their belt and shirt to get the pressure off of their stomach.

Another I/O commented that the space above the driver's compartment needs to be opened up and made bigger. This I/O suggested that room needs to be added to where the screens are

located because you can almost reach out and touch the screens. This gives a closed in, boxy feeling.

Finally, one I/O stated that a freeze-frame effect sometimes occurs during a scenario.

APPENDIX G

Test Driving the TDT

Three ARI researchers test-drove the TDT at the developing contractor's facility. An engineer cautioned the researchers not to stare at any one of the display screens but rather to frequently shift their area of focus across the three different display screens and the instrument panels. (I/Os at the TDT training site convey a similar warning to the trainees). Two of the three researchers did not experience simulator sickness. These two drove the TDT with the motion platform turned on and with motion off. At worst, they experienced mild "stomach awareness" comparable to what one might experience during the takeoff of a commercial airliner. In addition, there was a barely noticeable sensation involving focussing the eyes. The senior author intentionally ignored the warning not to stare at the screens. In addition, he performed driving maneuvers, for example rapid pivoting, which would be expected to produce simulator sickness. He experienced a sudden onset of sweating, eyestrain, and nausea, of which the later persisted for over an hour after leaving the simulator. (This same researcher drove an actual M1 tank months after his one session with the TDT. Despite having experienced simulator sickness in the TDT and the length of time that had passed he felt that there was significant transfer of training from his session on the TDT to M1 driving.)

Each of the researchers noticed that during the times when no computer generated display was being presented on the TDT displays, while a scenario was being loaded for example, there was an odd visual phenomenon involving eye focus. Reflections on the display screens seemed to cause an uncomfortable sensation as focal length shifted. Obviously there is no need for a trainee to look at the screens when a training scenario is not being presented but doing so may produce simulator sickness.

The researchers concluded that there were no obvious errors in the design or construction of the TDT. Motion and visuals seemed to be well synchronized. Perusal of the technical specifications of the TDT indicated that the specifications were well within simulation industry standards for factors such as asynchrony of visual and motion cues. ARI researchers did not attempt to verify that the TDT is functioning within those specifications.